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Is Locked Compression Plate Better than Limited Contact Dynamic Compression Plate in Treatment of Closed Middle Third Radius and Ulnar Fractures in Adults: A Short-Term Comparative Study

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Abstract

Background Forearm bone fracture is a commonly encountered fracture. The inception of locking compression plate (LCP) has revolutionized fracture management. With their dramatic success for articular fractures, there is a speculation that they might be more appropriate for diaphyseal fractures as well.

Objective To compare internal fixation of closed, middle third forearm fractures with LCP and limited contact dynamic compression plate (LC-DCP) in adults with respect to union rate, implant failure, functional outcome, and infection rate.

Methods Twenty-two patients with closed, middle third fractures of both the forearm bones were involved in this prospective, randomized, controlled study, which took place between February 2019 to January 2021. They were segregated into two groups based on open reduction and internal fixation with LCP (n=11) and with LC-DCP (n=11). Postoperative follow-up intervals of 1, 2, 6 weeks and 3, 6 months. The patients were assessed for implant failure, fracture union and function outcome of Andersons' criteria to assess union, forearm rotation, and wrist flexion-extension, and disabilities of the arm, shoulder and hand (DASH) score for patient related outcome at the latest follow up.

Results The mean age of the patients was 30.9 years (range 19-47 years) with mean follow up about of 2 years. The union rate in LCP group was (100%) whereas in LC-DCP was (81.8%), the p value was (0.4), which is not statistically significant. The p value for Quick DASH score and Anderson' criteria were (0.8 and 0.43), respectively which is also not statistically significant. No incidence of implant failure in both groups.

Conclusion Although LCP is an effective treatment alternative and may have a subtle edge over LC-DCP in the management of these fractures, their supremacy could not be certified. We deduce that surgical planning and expertise rather than the choice of implant are more pivotal for outstanding results.

Keywords Limited contact dynamic compression plate, locking compression plate, closed, middle third fractures, both bones of forearm

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List of abbreviations: AP = Antero-posterior, DASH = Disabilities of arm, shoulder, and hand, LC-DCP = Limited contact dynamic compression plate, LCP = Locked compression plate, ORIF = Open reduction and internal fixation

Introduction

Diaphyseal fractures involving the radius and ulna, so called ''both bone'' or ''double-bone'', forearm fractures are

common orthopedic injuries. These injuries can cause significant loss of function if inadequately treated. As the upper extremity serves to position the hand in space, loss of forearm motion and/or muscle imbalance resulting from a poorly treated fracture can be particularly debilitating. Preservation of the anatomic relationships of the proximal and distal radioulnar joints as well as the interosseous space is critical to preserving function [(1).]

It is essential to regain length, apposition, axial alignment, and normal rotational alignment while treating diaphyseal fractures of the radius and the ulna to gain good range of pronation and supination. The chances for the occurrence of malunion and non-union are greater because of the difficulties in reducing and maintaining the reduction of two parallel bones in the presence of the pronating and supinating muscles, which have angulatory as well as rotatory influences [(2)].

The objective of this study was to compare internal fixation of closed, middle third forearm fractures with locking compression plate (LCP) and limited contact dynamic compression plate (LC-DCP) in adults with respect to union rate, implant failure, functional outcome, and infection rate.

Methods

A prospective comparative randomized study was conducted from February 2019 to January 2021 including the follow up, at the Department of Orthopedic Surgery at Al-Imamein Al-Kadhimein Medical City. Twenty-two patients had been evaluated, five patients were female and seventeen were male, who had closed radius and ulna middle third fractures. The patient sample divided randomly by choosing every other patient into two groups: group 1 (11 patients) fixed by LCP, and group 2 (11 patients) fixed by LC-DCP.

In both groups, the radius fixed by volar (Henry) approach, which is offers good exposure of the whole length of the radius, and ulna fixed by direct subcutaneous approach.

The patients were collected and evaluated in Outpatient and the Emergency Department in our hospital and patients referred from other hospitals. All patients approached by the same surgeon team, and followed postoperatively at 1-week, 2-week, 6-week, 3-month, and 6-month. The current assessment was done based on history of the patients, clinical examination, and radiography.

A brief information about the surgery, implant, and the enrollment in the study was discussed with each patient and verbal agreement was taken.

Inclusion criteria

- Skeletally mature patients (closed physis).
- Both forearm bones, closed, middle third fractures.
- Acute presentation within 14 days of injury.
- (Transverse, short oblique) radius and ulna fractures.
- Low energy trauma.

Exclusion criteria

- Open fracture.
- Previous fracture in same limb.
- Pathological fracture.
- Associated distal radioulnar joint dissociation, elbow dislocation.
- Osteoporotic bone.
- Patients not fit for surgery.
- Neuropathic patient.
- Multiple traumas.
- Deformed radius and ulna.
- Vascular or neurological injury.
- Associated comorbid diseases (renal failure, uncontrol diabetes HbA1c more than 7.5%, heart failure).

The patients were prepared for the nearest elective surgery list (all were operated within the first 14 days of injury) after optimization of all the facilities and the patient`s general condition and performing all the laboratory investigations. At the day of surgery patient was admitted to surgical unit of orthopedic and ceftriaxone 1 g vial given intravenously within 1 hour before skin incision, after checking the

allergy condition to the drug. A volar Henry approach was utilized to fix the fractures of radius. Ulna was exposed through an incision over its subcutaneous border and its dorsal surface was plated. In both groups we started with fixation of the radius then the ulna. And each bone fixed by six cortices in each fragment. The patients in both groups were kept in the Hospital Orthopedic Ward under observation, active finger exercise encouraged immediately after surgery, paracetamol 500 mg vial (three times per day), ceftriaxone vial 1gm intravenously at 8 and 16 hours postoperatively, initial plain radiograph was taken before discharge to assess reduction, and the limb kept in elevation by arm sling for 14 days.

Simple oral analgesia (paracetamol) on need was prescribed for all patients. During this period, elevation, gentle finger motion, active and passive, together with shoulder motion can be started.

Follow up criteria for both groups

All patients in this study were followed-up in outpatient clinic after 1 week to change dressing and the wound inspected for signs of infection.

Then followed at 2nd week to inspect and assess the wound healing and stiches removed. Active assisted range of motion exercises, including gentle forearm rotation, elbow flexion and extension begin. Lifting and resisted exercises are restricted until radiographic signs of healing appear.

Then followed in 6th week and 3rd month for radiological assessment (AP and lateral plain radiograph was taken), for union and implant failure, and for clinical assessment of forearm rotation movements. Further followed up in the 6th month postoperatively for clinical and radiological union assessment, implant failure and for functional outcome assessment using Quick Disabilities of the Arm, Shoulder and Hand (DASH) scoring system [3] and Anderson et al. criteria [4]. All patients in both groups were followed up for the following parameters:

- ***Union***: assessed according to Anderson et al. Criteria [4]. Osseous healing was designated radiologically in AP and lateral radiographs. And absence of pain and tenderness at fracture site dictated the achievement of clinical healing.
- ***Functional outcome of forearm rotation and wrist flexion-extension***: assessed by Anderson et al. criteria [4]. Forearm Rotation and wrist flexion-extension measured using goniometer.
- ***Implant failure***: (plate breakage) or screws (pullout or breakage).
- ***Physical function and functional outcome***: assessed by Quick DASH score.
- ***Infection***: whether superficial infection (not reaching bone and joint and could be treated as outpatient with oral or intravenous antibiotics) or deep infection.

Results

All patients achieved union by 6th month interview (2 patients in group 2 developed delayed union), the same 2 patients have had superficial infection treated by oral antibiotics and changing dressing (Figures 1 and 2).

No patient in both groups had implant failure or loss of fixation. No patient in both groups had poor results with Anderson functional criteria or DASH score (Table 1).

Figure 1. Pre - and post-operative plain radiograph of a patient in group 2 where (1) is a plain radiograph of forearm showing both bone forearm fracture and (2) is 6 months after fixation with LCP with complete obliteration of the fracture line

Table 1. Number and percentage of follow up parameters

Parameter	Subdivision	LCP N (%)	LC- DCP N (%)	P value
Union	Perfect	11 (100%)	9 (81.8%)	0.4
	Delayed	0 (0.0%)	2 (18.2%)	
Functional outcome	Excellent	7 (63.6%)	4 (36.4%)	0.43
	Satisfactory	3 (27.3%)	5 (45.5%)	
	Unsatisfactory	1 (9.1%)	2 (18%)	
DASH score	Excellent	1 (9.1%)	1 (9.1%)	0.8
	Good	9 (81.8%)	8 (72.7%)	
	satisfactory	1 (9.1%)	2 (18.2%)	
Superficial infection	Yes	0 (0%)	2 (18.2%)	0.4
	No	11 (100%)	9 (90.9%)	
Failure of fixation or implant	Yes	0 (0%)	0 (0%)	1.00
	No	11 (100%)	11 (100%)	

Figure 2. A radiograph of patient from group 2 who treated by open reduction and internal fixation (ORIF) with LC-DCP. With (A) represents mid shaft fracture of both radius and ulna preoperatively and (B) represents postoperative fixation of both bones by LC-DCP after 6 months showing complete union

Discussion

Fracture of both bones of the forearm are relatively common injuries, which can challenge the treating physician. Healing occurs after closed treatment but malunion with resultant decreased rotation of the forearm, is common and has been associated with poor outcomes. Rotation of the forearm is a complex interaction between the radius and the ulna and restoration of movements depend upon both an accurate reduction of fractures and early initiation of postoperative movements. Loss of rotation impedes function of the upper limb and activities of daily living [5].

Open reduction and plate fixation has been the standard treatment of adult diaphyseal forearm fractures [6], but the most effective type of plate fixation for diaphyseal fractures of forearm bones has not been well defined [7].

Locked plates do not rely on frictional force between the plate and the bone to achieve compression and provide absolute stability. Thus, the local blood supply under the plate to be preserved [8], thereby leading to superior bone healing and minimal complications. It has been proved to be valuable in situations like osteoporosis, comminuted fractures, osteotomy, complex intraarticular fractures or fractures in close proximity to the joints [9].

The sample size in this study was (22) patients. The mean age included in this study was about 30.9 years, (77.3%) males and (22.7%) females, of the total patients, right hand affected in about (73%) while (23%) got left side fracture, these variables (age, gender, hand dominancy) are normally distributed in our community because of most workers are active males from middle age group with right hand dominancy, which is comparable to Gill et al. study [10] for

comparison between LCP and LC-DCP in diaphyseal fracture of radius and ulna in adults. The mean age was 32 years, male (74%), female (26 %), right hand (57%) and left hand (43%), which is also comparable with Saikia et al. [11] study. They were (25) males (70%) and (11) females (30%), with an average age of (30.5) years.

These two studies states that females tend not to have as many radius and ulna fractures as the male counterparts because they tend not to partake in the same level of high velocity and sport activity.

Regarding to union rate, this study had 2 patients with delay union (2 of 11) in group 2 (18%) and union occurred without resorting to any secondary procedure. While in group 1 we did have (100%) union, (11 of 11) patients, and there was no significant statistical difference between LCP group and LC-DCP group.

These results were comparable to Gill et al. study [10], which had (88%) union, (8%) delay union and (4%) nonunion in 26 patients with diaphyseal radius and ulna fracture fixed by LC-DCP, and (96%) union and (4%) delay union in 26 patients with closed diaphyseal radius and ulna fracture fixed by ORIF with LCP. The difference between two groups was not significant.

In Saikia et al. study [11], the sample size was (36) adult patients with closed diaphyseal radius and ulna fracture, had (100%) union with (18) patients fixed with LCP, and (94%) had union, and (6%) had delay union with (18) patients fixed with LC-DCP. The difference was not significant and could not prove the superiority of LCP because He suppose the quality of reduction and stability of fracture which determine the union rate. Leung and SP Chow prospective study, locking compression plate in the treatment of forearm fractures: reported that the LCP is an effective bridging device used for treating comminuted fractures, but for treating simple fractures its superiority over conventional plating is yet to be proven. Reddy et al. [12] reported the mean time of union for the forearm fixed with LCP was found to be (18 weeks) in comparison to (16 weeks) for the LC-DCP group and this result is not significant. Vishwanath et al. [13] study consists of 50 cases of fracture both bone forearm fractures. All cases were treated operatively with 3.5 mm LC-DCP and reported (98%) union rate and concluded that LC-DCP can be considered the best mode of treatment for closed diaphyseal fractures of both forearm bones because it minimizes vascular damage to the plated bone segment.

More than three studies as shown above agreed with the result in this study as no significant difference between LCP and LC-DCP for closed diaphyseal fracture of the radius and ulna. This may explain as the quality of reduction, stability of fracture, proper application of the biomechanical principles of plating and not the type of plate, which determine the union outcome.

Regarding infection, in this study, there was no infection in LCP group, whereas two patients in group (2) had superficial infection within the first week which subsided with antibiotic and dressing. Both patients ended up with delayed union (>6 months), both of them were smokers and one was diabetic. There is no significant statistical difference between LCP group and LC-DCP group. This result is comparable with Gill et al. [10] reported (88%) no infection, (8%) superficial infection and (4%) deep infection in LCP group, and (3%) superficial infection and (3%) deep infection in LC-DCP group. Saikia et al. [11] had (6%) deep infection in LCP group and (11%) superficial infection in LC-DCP group. And these results are not statistically significant. Also, in Leung and Chow [6] and Mohamed Shakeeb et al [14] reported that no significant difference. This could be explained upon the fact that the infection caused by patient factors like smoking and comorbidities and not related to implant.

Regarding functional outcome through 6th month follow up interval using Anderson et al. criteria [4], the results of this study showed no significant difference between two groups, this thesis reported (63.6%) excellent outcome, (37.5%) satisfactory, and (33%) unsatisfactory in (group 1), and (36.4%) excellent outcome, (62.5%) satisfactory, and (66.7%) Unsatisfactory outcome in (group 2).

And this result was comparable to Saikia et al. [11] who reported (88%) excellent outcome, and (12%) satisfactory outcome in LCP group while reported (88%, 6%, 6%,) excellent, satisfactory, and unsatisfactory, in LC-DCP group respectively. Gill et al. [10] in the LC-DCP group, (57%) excellent results, (32%) satisfactory, (7%) unsatisfactory and (4%) was recognized as failure. In the LCP group, (77%) excellent, (19) satisfactory and (4) unsatisfactory. These results are better for LCP but not able to statistically prove better results of LCP. Vishwanath et al. [13] reported LC-DCP gives excellent functional results in most of the patients. Leung and Chow [6] reported the functional outcome of LCP gives excellent results.

Reddy and Reddy [15] reported the functional results were almost same in both groups, in spite of different rates of radiological union.

Regarding functional outcome through 6th month follow up interval using DASH score, the results of this study showed (50%) excellent outcome, (52.9%) good outcome, and (33.3%) satisfactory outcome in (group 1). While in (group 2) the results showed (50%) excellent outcome, (47.1%) good outcome, and (66.7%) satisfactory outcome. The result of this study showed no significant difference between two groups. These results were comparable with Gill et al. [10] and Saikia et al. [11], these studies showed no significant difference between LCP and LC-DCP groups. Henle et al. [16] compared LCP with the LC-DCP when used for "bridging technique" and "axial compression." fixation and concluded that the LCP did not demonstrate any superiority over LC-DCP in terms of functional or clinical outcomes. Mohamed Shakeeb et al. [14] reported that the outcome is determined by using the proper principles of plating, and the LCP gives better results in comminuted both bones forearm diaphyseal fractures in comparison to dynamic compression plate even though cannot prove better results overall forearm fractures. This could explain that early mobilization prevents soft tissue contracture, muscular tethering and improves the vascularity.

Regarding the implant failure (plate breakage) or screws (excursion or breakage). This study showed no implant failure in both LCP and LC-DCP groups. Saikia et al. [11] reported no implant failure, but Gill et al. [10] had (1 of 28) case with loosening of LC-DCP. Vishwanath et al. [13] reported (2%) implant failure in LC-DCP.

In conclusion, although LCP is an effective treatment alternative and may have a subtle edge over LC-DCP in the management of these fractures, their supremacy could not be certified. We deduce that surgical planning and expertise rather than the choice of implant are more pivotal for outstanding results.

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Author contribution

All the authors contribute to this article by their patients and participate to the data collection and statistical analysis.

Conflict of interest

The authors declare that they have no conflict of interests.

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