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Dynamic Compression Plate versus Locking Compression Plate Fixation in Adult Forearm Fractures: A Prospective Interventional Study

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ABSTRACT

Introduction: Injuries resulting from traffic accidents, industrial accidents, natural disasters and assault are the cause of most fractures of the forearm and it is very important to regain the length, apposition, axial alignment and rotational alignment of the radius and ulna while treating diaphyseal fractures to achieve a good range of motion. In such cases, open reduction and internal fixation are recommended.

Aim: To determine the effectiveness of Locking Compression Plates (LCP) and Dynamic Compression Plates (DCP) in treating adult forearm fractures.

Materials and Methods: A prospective interventional study was conducted from September 2020 to September 2021 in which 30 patients with both bone forearm fractures underwent open reduction and internal fixation with a LCP (n=15) or a DCP (n=15) at the Dr. D.Y. Patil Medical College, Hospital and Research Centre, Pimpri, Pune, India. For each LCP and DCP operated patient, radiographic findings regarding fracture union and functional outcomes regarding elbow joint range of motion was evaluated. Appropriate parametric tests (Chi-square test, Independent t-test) were conducted to identify significant differences in functional outcomes between the two interventions.

Results: Out of total, 13 (86.7%) patients each who underwent both the DCP and LCP fixation had excellent outcomes, though the results were not significant according to Anderson LD et al., grading system. Although, it was statistically insignificant (p-value=0.18), patients who received LCP took less time to heal their fractures than those who received DCP. There was no significant difference between patients treated with DCP and those treated with LCP when it comes to achieving a complete range of motion (p-value=0.99).

Conclusion: In terms of functional outcome, both the patient groups who were operated on with DCP as well as LCP had no significant difference. Proper preoperative planning, good patient care, proper surgical technique with minimal adjacent soft tissue damage, strict aseptic conditions, proper follow-up, and rehabilitation along with patient education are all required for good functional outcomes.

Keywords: Complications, Elbow joint, Fracture union, Plating, Range of motion

INTRODUCTION

Traffic accidents, industrial accidents, natural disasters and assaults are becoming more common, resulting in more fractures and a higher morbidity rate in many developing countries. They are the main pandemics of the modern era. The majority of upper-limb fractures involve both forearm bones. Although, surgical treatment for these fractures can be effective, a proper anatomical reduction of the fracture is required for good postoperative function [1]. Morbidity rates rise due to delayed hospitalisation, improper stabilisation of fractured limbs, nerve and artery damage. The radius and ulna are two bones in the forearm that move. The radius and ulna are two bones in the forearm that move. They are connected to each other by proximal and distal radioulnar joints, along with an intraosseous membrane in between them [2]. Also, several muscles are introduced into the hand, providing support between the elbow and wrist. As a result, both the bones of the forearm, the ulna and the radius, are stabilised. When these bones get fractured, anatomic reduction and internal fixation are required to restore movement of the elbow, forearm and wrist along with grip strength [2].

The forearm is an important part of the upper limb's rotational stability. Forearm rotation and elbow rotation allow the hand to be positioned over a full 360-degree curve of motion. The range of motion of the elbow, including flexion and extension, is critical in performing daily activities and exercise [3]. Forearm fractures in adults are typically treated with open reduction and internal fixation. It is also commonly treated with dynamic compression plates [4,5]. A novel implant system with two treatment modalities has been developed to continue the transformation [4].

A dynamic compression plate is used, which has been conventional plating in internal fixation of isolated radius and ulna fractures for a long time. It has the advantage of less tissue damage, minimal surgical time during fixation and easy availability [5].

In some ways, Locking Compression Plates (LCP) combines the basic properties of locking plates and dynamic compression plates [5]. LCP is the result of these combinations, and it adheres to the most recent plating technology. It is intended to maintain fracture stability while ensuring blood flow to the bone and soft tissues, which is pivotal in fracture healing [5]. Because the screw heads on the plate's bottom are conically threaded, LCP has the properties of both Limited Contact- Dynamic Compression Plate (LC-DCP) and Point Contact-Fixator (PC-Fix) system. Additionally, comminuted fractures can be physiologically repaired with LCPs using the bridge plate method [5]. According to research, the LCP speeds up fracture healing and reduces the likelihood of delayed union and non union [6]. The LCP has features that produce an angled, stable screw plate mechanism. This plate fixation method relies on the threaded plate-screw interface to hold the bone fragments in place and does not require abrasion between the bone-like conventional plating and plate.

The LCP has been shown to provide a stronger fixation than the Dynamic Compression Plate (DCP) and can be implanted using the bridging plate technique, allowing for biological fixation of the communited fractures. In biomechanical studies, LCPs have been found to provide better mechanical and physiological properties than DCPs [5]. LCP is said to have benefits such as accelerating fracture healing and reducing malunion and non union concerns [6].

Refractures and cortical porosis in DCPs were thought to be caused by an increase in plate bone contact, which hampered circulation in the cortex [6]. According to this approach, the limited contact DCP (LC-DCP) was developed to minimise plate interference with cortical perfusion, thus reducing cortical porosity [7]. Plate bone contact was reduced to non existence after the invention of the point contact fixator [8]. Although, the LCP characterises the latest progress in plate development, its usage in fractures with simple configuration and in advantage over conventional plating system (LC-DCP) is yet to be proved [9]. There is a need for such an implant system that will avoid all of these complications while also providing better functional outcomes. As a result, the aim of the study was to determine the effectiveness of locking and dynamic compression plates in the treatment of adult forearm fractures.

MATERIALS AND METHODS

This prospective interventional study was conducted in Orthopaedic Department at Dr. D.Y. Patil Medical College, Hospital, and Research Centre, Pimpri, Pune, Maharashtra, India, from September 2020 to September 2021. Informed consent was obtained from all participants prior to surgery and the Institution Ethics Committee approved the study with approval number IESC/PGS/2019/107.

Inclusion criteria: All patients admitted to the hospital with both bone forearm fractures who were willing to operate with informed consent and aged more than 18 years were included in the study.

Exclusion criteria: Patients with forearm compound fractures, unwilling to undergo surgery, medically unsuitable for surgery and age less than or equal to 18 years were excluded from the study.

The study included 30 patients with both forearm bone fractures underwent open reduction and internal fixation with either of the method:

- Locking Compression Plate (LCP): Included 15 patients.
- Dynamic Compression Plate (DCP): Included 15 patients.

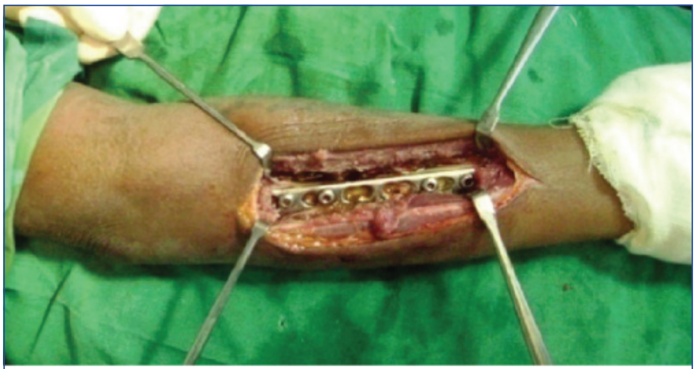
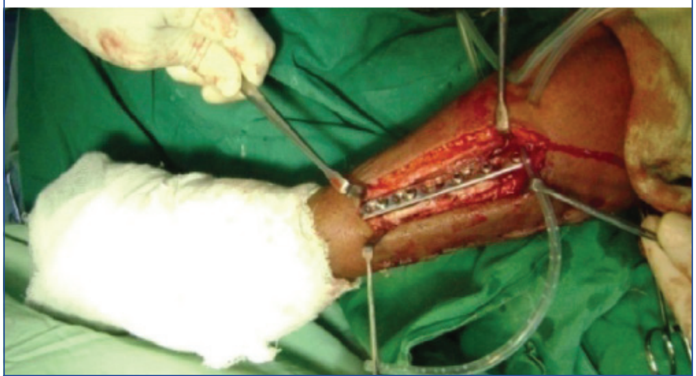
A thorough history was obtained from the patient and attendants upon arrival to disclose the mechanism of damage and the level of trauma. A thorough examination was performed to rule out fractures at other locations. Anteroposterior and lateral radiographs of the radius and ulna were taken. The limb was immobilised in the plaster of paris above elbow slab using a sling.

Surgical Procedure

A volar Henry incision was used for radius fractures in the middle and distal regions, while a dorsal Thompson incision was used for the proximal third area [Table/Fig-1]. The ulna fractures were addressed via a subcutaneous border incision [Table/Fig-2] [2,5,7]. The periosteum was not harmed in any way.

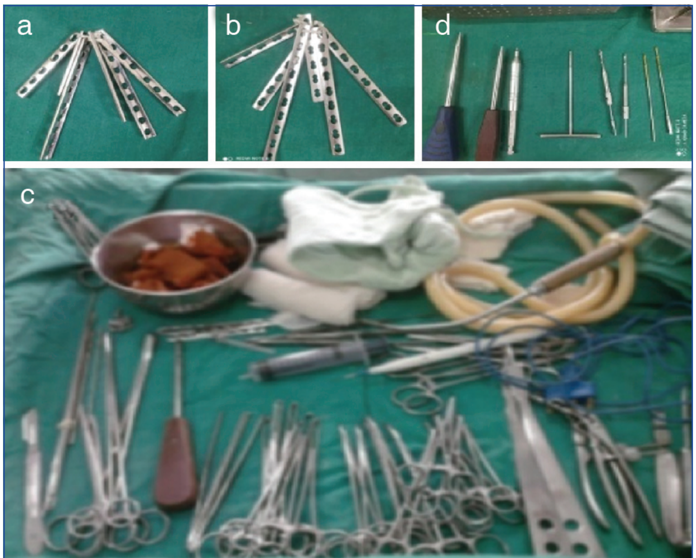

[Table/Fig-1]: Volar approach for for radius fixation.
[Table/Fig-2]: Subcutaneous approach ulna. (Images from left to right)

The uncomplicated fractures were stabilised first to assess the length and alignment of both bone forearm fractures. In the lack of explicit references to the rotation, the fractures were reduced temporarily, and the rotation was controlled once the other fracture was reduced. The locking screws were inserted in the other holes following compression with at least one unlocked screw proximal or distal to the fracture line in the uncomplicated transverse fractures which were repaired with the LCP. After achieving compression on the fracture line, with the interfragmentary lag screw method utilising the hole on the plate in the oblique fractures where the LCP was utilised, the locking screw was put in the other holes [Table/Fig-3]. Fixation was given by locking screws after getting the length and alignment by determining the proper length of the plate using the bridging method in the comminuted fractures in which the LCP was utilised [Table/Fig-4]. After fracture reduction, two compression screws were introduced proximal and distal to the fracture line, followed by the insertion of additional screws in patients who had fracture fixation utilising. The [Table/Fig-3,4] show the fixation of fracture after the adequate reduction.

[Table/Fig-3]: Radius was adequately reduced and fixed with 3.5 mm LCP.
[Table/Fig-4]: Ulna was fixed with 3.5 mm LCP.

In all cases, a 3.5 mm LCP or DCP plate has been used [Table/Fig-5]. The investigators tried to establish fixation with a total of three screws (six cortical) on both sides of the fracture line. Once the tourniquet was removed and haemostasis was achieved, a drain was inserted and the incision was closed. For two weeks, a splint was used. Except for supination and pronation, wrist and elbow Range of Motion (ROM) exercises were begun immediately while the arm was still in the splint.



[Table/Fig-5]: Implants and instruments used; a) DCP; b) LCP; c) Instruments used for the procedure; d) Drill bits, drill sleeves, screw drivers used in the fixation.

All patients were followed-up at monthly intervals for the first three months and again six months later. We used the Anderson LD et al., grading system to confirm the functional result [Table/Fig-6] [9,10]. Numerous parameters were assessed, including the ROM as well as the fracture's healing and union.

Result	Union	Flexion extension at elbow joint	Supination and pronation of forearm
Excellent	Present	<10% loss	<25% loss
Satisfactory	Present	<20% loss	<50% loss
Unsatisfactory	Present	>20% loss	>50% loss
Failure	Non union with or without loss of motion		

[Table/Fig-6]: Anderson LD et al., scoring system, based on their range of motion [9,10].

A joint's full ROM refers to its ability to move through its entire ROM [11,12]. The term "limited range of motion" refers to a joint that has difficulty moving. It may be limited due to a problem within the joint, swelling around the joint, muscle stiffness, or pain [13]. Elbow flexion and extension were measured as a ROM around the elbow joint. Supination and pronation of the forearm were also assessed. Radiographic assessments included the investigation of callus bridging and obliteration of fracture lines.

When there was a restoration of cortical continuity, loss of a distinct fracture line and the formation of callus, the fracture was said to be radiologically united [13]. When a fracture line cannot be seen and there was no subjective issues, it is deemed radiologically as a union. A delayed union occurs when a fracture heals after six months without the need for additional surgery. A non union fracture requires a second operation or additional procedures if it does not heal within six months [14].

STATISTICAL ANALYSIS

Functional effects of DCP and LCP were inferred from statistical analysis performed using Statistical Package for Social Sciences version 17.0 software (SPSS, Inc., Chicago, IL, USA). Appropriate parametric tests (Chi-square test, independent t-test) were conducted to identify significant differences in functional outcomes between the two interventions.

RESULTS

The average age of the participants in the study was 35.7±9.2 years. This study found a male predominance amongst the 30 patients; 17 (56.7%) of the patients were men, and 13 (43.3%) were females [Table/Fig-7].

Age range (years)	Locking compression plates		Dynamic compression plates	
	Male	Female	Male	Female
18-28	2	4	2	1
29-38	2	2	3	4
39-48	2	2	2	0
49-58	1	0	3	0
Total	7	8	10	5

[Table/Fig-7]: Age range of the participants.

There was no significant difference between patients treated with DCP and those treated with LCP when it comes to achieving a complete range of motion [Table/Fig-8].

Type of plates	Full elbow ROM n (%)	Limited elbow ROM n (%)
DCP	13 (86.7%)	2 (13.3)
LCP	13 (86.7)	2 (13.3)
Total	26	4

[Table/Fig-8]: Comparison of ROM between two groups.
Chi-square test; p-value=0.99 (not significant)

In this study, within six months, all patients (100%) had a successful union. Although, it was statistically insignificant (p-value=0.18), patients who received LCP took less time to heal their fractures than those who received DCP [Table/Fig-9].

Groups	Number of patients	Mean duration of fracture union (in weeks)	p-value (Independent t-test)
DCP	15	12.4±3.4	0.18
LCP	15	10.8±2.9	

[Table/Fig-9]: Time of fracture union between two groups.

In the study, 13 patients after DCP surgery had excellent outcomes, while two patients had satisfactory results. While the 13 patients who underwent LCP surgery had excellent results, while two patients had satisfactory results [Table/Fig-10].

Type of plates	Excellent (n, %)	Satisfactory (n, %)
DCP	13 (86.7%)	2 (13.3%)
LCP	13 (86.7%)	2 (13.3%)
Total	26	4

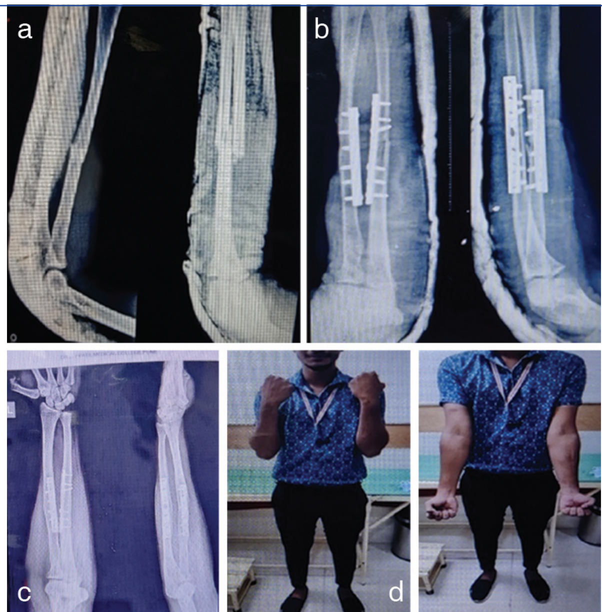
[Table/Fig-10]: Functional results between the two groups.
Chi-square test; p-value=0.99 (not significant)

Only one patient (6.7%) developed a superficial infection and posterior interosseous nerve damage following DCP and LCP surgery. Both complications were resolved on their own. The remaining 93.3% of patients do not experience any major complications [Table/Fig-11].

Type of plates	Complication	
	Present (n, %)	Absent (n, %)
DCP	1 (6.7%)	14 (93.3%)
LCP	1 (6.7%)	14 (93.3%)
Total	2	28

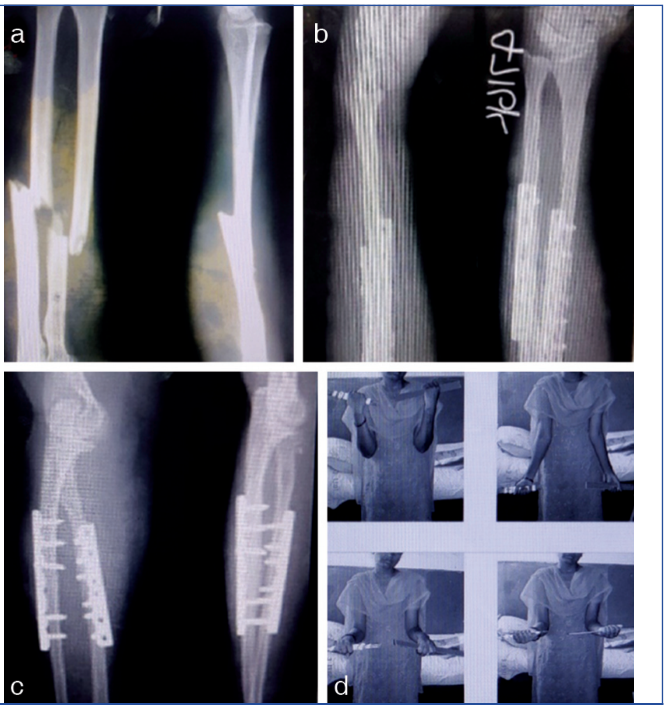
[Table/Fig-11]: Type of plate and associated complication.
Chi-square test; p-value=0.99 (not significant)

Several patients who have been treated with LCP and DCP are discussed. A patient who was diagnosed with a left both bone forearm bone fracture was admitted. He was operated on with an open reduction internal fixation with DCP six months after surgery, there was a successful fracture union, with an excellent functional outcome [Table/Fig-12a-d].



[Table/Fig-12]: a) Preoperative X-ray; b) Postoperative X-ray; c) After six months postoperative X-ray; d) Clinical photograph of patient showing excellent functional outcome.

A second patient with left both bones forearm fractures was admitted, and she underwent open reduction internal fixation with a locking compression plate. The fracture union was achieved at six months postoperatively with an excellent functional result [Table/Fig-13a-d].



[Table/Fig-13]: a) Preoperative X-ray; b) Postoperative X-ray; c) After six months follow-up X-ray; d) Clinical photograph of patient.

DISCUSSION

Effective upper limb rehabilitation requires two factors i.e, anatomic reduction and strong and secure fixation. For many years, dynamic compression plates and screws were used to accomplish this [15]. Following that, it remained unchanged until the introduction of locking compression plates, which enabled improved rigid fixation, rapid re-functionalisation and faster recovery.

The 30 patients with both bone forearm fractures were treated and internally fixed with 3.5 mm LCP and DCP. Females accounted for 13 (43.3%) of the 30 patients in this study, while males accounted for 17 (56.7%), indicating a male predominance in industry, fields, travel, and sports. Dodge HS and Cady GW, reported in their study that 89% of males and 11% of females were involved [16]. The study by William A and Mast WJ, had a male to female ratio of 67:33 [17]. The Leung F and Chow SP, is made up of 82.6% males and 17.4% females [18]. Present study findings corroborate the study by Dodge HS and Cady GW and Moed BR et al., with the most common type of fractured forearm in the second decade of life [16,19].

In this study, within six months, every patient (100%) had a union of their fracture. In patients with DCP, the meantime to union was 12.4 weeks, with a standard deviation of 3.4 weeks, and in patients with LCP, the meantime to union was 10.8 weeks with a standard deviation of 2.9 weeks. This shows that patients with the LCP took less time to heal the fracture than those who received the DCP. Still, statistically, there was no significant difference in their union time.

According to Saikia K et al., in the LCP group, fractures union occurred at a mean of 16 weeks, compared to 14 weeks for those who have a DCP fixation. One LC-DCP operated patient had no union. The researchers in that study asserted that LCP and LC-DCP produced non significant results [10]. According to study by Leung F and Chow SP, 32 of 45 patients with forearm fractures treated with LCPs experienced union at an average of 20 weeks [20]. This study demonstrated that bridging with LCP assisted in the repair of diaphyseal forearm fractures [20]. In another study, Stevens CT and Duis HJ, compared DCPs and LCPs. Unions have always been formed regardless of the disparity. Both groups had unions when compression was taken into account. Researchers discovered that applying axial compression to a fracture may affect the time required for it to heal, not the type of plate used [21].

According to investigative data, LCPs outperform DCPs and all locking plates in osteoporotic fracture saw bone models [22,23]. Despite this, clinical trials have failed to demonstrate that LCPs are superior to conventional plates in treating forearm fractures [10,21]. Henle P et al., discovered that LCP plating can be used to repair forearm diaphyseal fractures with clinical and functional outcomes compared to those associated with conventional DCP implants [24]. Droll KP et al., reported that plating decreased patients' strength by 30% and their Disabilities of the Arm, Shoulder and Hand (DASH) and SF-36 scores by 30% [25].

When it comes to complications, only one patient (6.7%) with DCP and LCP developed a superficial infection and posterior interosseous nerve damage, according to the present study. This is comparable to study by Anderson LD et al., finding that 2.9% of patients had posterior intraosseous nerve damage, 2.9% had non union, 2% had surgical site infections, and 1.2% had radioulnar synostosis [9]. Furthermore, Chapman MW et al., discovered that 2.5% of patients had surgical site infections, 2.3% had non union, 1.5% had posterior intraosseous nerve damage, and 2.3% had radioulnar synostosis [4]. This demonstrates that, in comparison to these studies, the current study encountered a very small number of complications that can also be avoided [26,27].

On comparison of present study, for the functional outcomes obtained in the previous studies, Anderson LD et al., discovered that 52 (50.9%) instances were excellent, 37 (34.9%) were good, 12 (11.3%) were unsatisfactory, and 2 (2.9%) failed [9]. According to Leung F and Chow SP, 98% of patients experienced excellent outcomes, while 2% experienced satisfactory outcomes [18]. In the present study, 13 (86.7%) patients had excellent outcomes following DCP surgery, while 2 (13.3%) patients had satisfactory outcomes. In present study, 13 (86.7%) patients had excellent outcomes following LCP operations, whereas 2 (13.3%) patients had satisfactory outcomes. According to this, no LCP or DCP fixation was found to cause significant changes in bone forearm fracture fixation.

According to study by Azboy I et al., union was achieved in all patients and there was no significant difference was found regarding the time to union between the groups (p-value>0.05) [28]. Despite LC-DCP requiring less time of union (16 weeks) than LCP (18 weeks), the study by Reddy BJ et al., could not prove the superiority of LCP over LC-DCP, but the proper application of the principles of plating decides the outcome [29].

Also, according to other study by Lee YC and Kang HJ, the mean time to union was not different in simple fractures (15.5 weeks in LCP group vs. 13.8 weeks in DCP group) but it was different between two groups in mutifragmentary fractures (14.8 weeks in LCP groups vs. 24 weeks in DCP group) showing that in multifragmentary fractures, LCP can shorten radiologic union time than using DCP [30].

Significantly, long-duration follow-up and more participant patients should have been involved in the study. With more subjects being followed for a longer period, the usage of LCP and DCP can be clearly defined.

Limitation(s)

Small sample size was the major limitation of the study. Patients with compound forearm fractures, or those who were unfit for surgery due to various other health conditions were not included.

CONCLUSION(S)

In terms of functional outcome, both the patient groups who were operated on with DCP as well as LCP had no significant difference. Proper preoperative planning, good patient care, proper surgical technique with minimal adjacent soft tissue damage, strict aseptic conditions, proper follow-up and rehabilitation along with patient education are all required for good functional outcomes.

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