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A comparative study of internal fixation of forearm fractures using locking compression plate and dynamic compression plate

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Abstract
Background: Fractures of forearm bones are common in direct trauma often while protecting one's head, road traffic accidents, fall from height and sports activities. Open reduction and internal fixation are the treatment of choice in these cases. Locking Compression Plate (LCP) is a new fixation device in treating these fractures. This study has been carried out to compare the role of Locking Compression Plate (LCP) with Dynamic Compression Plate (DCP) in treating these fractures.
Methods: A prospective study was done from September 2017 to March 2019, including forty eight patients with fractures of radius and ulna. In Group I (DCP group), twenty four patients were subjected to open reduction and internal fixation with 3.5 mm stainless steel DCP and non-locking screws. In Group II (LCP group), 24 patients were managed by open reduction and internal fixation using 3.5mm stainless steel LCP and locking head/non-locking screws. All patients were followed up at monthly interval until union. Clinical assessment regarding functional outcome was done at the final follow-up.
Results & Conclusion: The mean union time in Group I (DCP group) was 13.67 weeks (range, 8-24 weeks, SD3.67). In Group II (LCP group), the mean union time was 16.25 weeks (range, 12-24weeks, SD3.14). Excellent & satisfactory results were observed in 87.5% cases in Gp I and 91.67% cases in Gp II. On statistical analysis, there was no significant difference in the mean union time and functional outcome in Gp I and Gp II. Both internal fixation devices were equally effective in treating diaphyseal fractures of forearm.

Keywords: Diaphyseal forearm fracture; locking compression plate, dynamic compression plate

Introduction
Fractures of forearm bones are common in direct trauma often while protecting one's head, road traffic accidents, fall from height and sports activities. It is essential to regain length, apposition, axial alignment and normal rotation while treating diaphyseal fracture of forearm. Open reduction and internal fixation with various types of plates and intramedullary nailing is the treatment of choice in displaced fractures of forearm in adults. Internal fixation with Dynamic Compression Plate (DCP) is a frequently carried out surgical procedure for these fractures. The DCP not only supports fractured bone but also produces compression at fracture site and can work as a bridging plate. It acts by causing friction between the plate and bone, which is generated by tightening the screws that brings two surfaces together. The stability of DCP depends on tightness of screws, with increasing load cycles, there is reduction of friction force and leads to plate loosening. If this phenomenon occurs early, it makes fracture unstable and can lead to implant failure. In case of metaphyseal fractures, comminuted fractures and in osteoporotic bones, it is difficult to achieve strong fixation. Reduction of periosteal blood supply and reduced vascularity of the fracture fragment, following application of DCP has also been described in the literature. The conventional DCP has been associated with implant failures, delayed union and non-union in some studies [1, 2].
To overcome these complications, Association for Osteosynthesis (AO) group has devised the Locking Compression Plate (LCP). This plate has combination hole, which provides the choice of angularly stable locking screw fixation or dynamic compression at each single screw hole.

The LCP can be used either as an internal fixator, preserving the vascular supply of the fracture fragment, or as a standard DCP. In case of LCP, fracture fragments are stabilized by attachment of screw to the plate in a rigid, fixed angle unit, which is possible by thread in the screw head and combination hole in the plate. This mechanism makes the fixation more resistant to loosening resulting from cyclic loading. Since all screws are locked to the plate at fixed angle, they fail as a unit rather than individually [3, 4]. This design feature has advantage in presence of osteoporosis, where the cortex is thin and plate to bone compression cannot be achieved effectively. Reduced plate-to-bone contact provided by LCP also protects the vascularity of the cortex and surrounding soft tissues [5].

In simple fracture, the LCP provides more rigid fixation and if used without axial compression at fracture site, it can lead to delayed union or non-union. The present study has been carried out to evaluate the use of LCP and DCP in simple fractures of forearm bones and describe the union time and incidences of complications.

Materials and Methods

A prospective study was done from September 2017 to March 2019 including forty eight patients with fractures of radius and ulna. Study included fractures of mid shaft within two weeks of injuries were selected. All the patients with open fractures, pathological fractures and patients with more than 55 years were not included in this study to rule out other extraneous factors influencing the fracture healing. Patients were divided into two groups. Each group included 24 patients.

In Group I, internal fixation of fracture was carried out using 3.5 mm stainless steel Dynamic Compression Plate (DCP) and in Group II internal fixation done using 3.5mm stainless steel Locking Compression Plate (LCP) and locking head screws/non-locking screws. All Radial fractures were exposed by volar approach and ulnar fractures were approached by posterior approach. In Group I (DCP group), after the fracture was reduced, a conventional screw was inserted in neutral mode to secure the plate onto the bone. Depending on the fracture configuration, the second screw inserted was either in neutral mode for a bridging technique or a compression screw for inter-fragmentary compression. In Group II (LCP group), locking head screw was inserted first followed by insertion of either compression screw or locking head screw for bridging technique. Remaining screws, in Group II were locking head screws on either side of the fracture. Prophylactic antibiotics were given for 48 hrs in perioperative period. All patients were instructed to keep the arm elevated and early active movement of the wrist and elbow started as early as the first postoperative day. Normal daily activities were resumed after 2 to 3 weeks, while manual work or sports activities involving the injured arm were avoided until bony union has occurred. Patients were followed up in OPD, clinically and radio-logically at monthly interval until the union. Preoperative photograph of a patient with fracture of radius & ulna is shown in Fig-1. Average duration of follow up was 10 months. Clinical parameters observed at follow up included, condition of operation scar, pain and tenderness at fracture site, abnormal mobility and clinical deformity. Radiological parameters recorded at the time of follow up included, amount of bridging callus, visibility of fracture line and any evidence of hardware failure.

Fracture was considered to be united when clinically there was no pain, tenderness or abnormal mobility at fracture site and radiologically there was obliteration of fracture line or the presence of bridging periosteal callus in radiographs after six months.

We classified the individual radial and ulnar fractures into three groups: (1) those which healed in less than six months were classified as unions; (2) those which required more than six months to unite and had no additional operative procedure were classified as delayed unions; and (3) those which failed to unite without another operative procedure were classified as non-unions.

Clinical assessments regarding function was undertaken at the final follow up. The functional results were rated according to Anderson *et al* criteria [6], as given below

1. Excellent - union with less than 10 degrees loss of flexion-extension and less than 25 per cent loss of pronation- supination;
2. Satisfactory - union with less than 20 degrees loss of flexion-extension and less than 50 per cent loss of pronation - supination;
3. Unsatisfactory - union with more than 30 degrees loss of flexion-extension and greater than 50 per cent loss of pronation-supination;
4. Failure - non-union with or without loss of motion.

Results

A total of 48 patients were treated, 40 were male and 8 were female. Age & sex wise distribution of patients is given in Table-1. Fracture of forearm bones were more common in males (83.33%) than in females (16.67%) in the present study. The mean age of the patient in Group I was 27 yrs (range 5-45 yrs, SD11.47), while in Group II it was 24.6 yrs (range 9-50yrs, SD11.17). Eleven had radial bone fractures, 7 had ulnar bone fracture and 30 had both bones fractures. The details of the fractures are described in Table-2. In Group I (DCP group), 39 diaphyseal fractures of radius and ulna in 24 patients were subjected to open reduction and internal fixation with 3.5 mm stainless steel dynamic compression plate and screws. In Group II (LCP group), 39 fractures of radius and ulna in 24 patients were managed by open reduction and internal fixation using 3.5mm stainless steel locking compression plate and locking head screws/ non-locking screws. The details of the fractures in each group are given in the Table No -3. The time interval from trauma to operation was less than one week in all the cases.

Three patients (2 from Group 1 and one from Group 2) were lost to follow up within 3 months and all of them were with both bones fractures and they had been excluded from the study.

Mode of injury of the fractures is given in Table No -4. Road traffic accidents had been the cause of fracture in maximum no of cases (52.08%), while accidental slip and fall had been the second most common cause (33.3%). Transverse /oblique fractures were most commonly seen fracture pattern.

Fracture union: There was no nonunion. Fracture union has occurred earlier in Group I (DCP group) than in Group II (LCP group). The mean union time in Group I (DCP group) was 13.67 weeks (range 8-24 weeks SD 3.67). Delayed union occurred in one patient in this group. In Group II (LCP group), the mean union time was 16.25 weeks (range 12-24 weeks SD 3.14). Delayed union occurred in one patient. Neither patient required additional bone grafting procedures. To assess if there is statistically significant difference in the mean union time by two surgical procedures, unpaired' test was used.

t value= -2.622
p value= 0.012

The difference in mean union time was not statistically significant as revealed by unpaired' test.

Infection: There was no evidence of deep infection in any patients. Superficial infection was seen in only one patient in Group I, which subsided following local dressings and antibiotic therapy.

Functional outcome: Functional results of fracture fixation in both groups were categorized according to Anderson *et al* [6] criteria, which were based on status of fracture union and range of movement at the final outcome at the end of one year. Details of functional outcome depicted in Table No-5.

Excellent & satisfactory results were observed in 87.5% cases in Gp I and 91.67% cases in Gp II. On statistical analysis, there is no significant difference in the functional outcome in Gp I and Gp II (p>0.05).

Table 1: Age and sex distribution (N=48)

S. No	Sex	Group I (DCP)	Group II (LCP)
1	Male	21	19
2	Female	3	5
3	Age range	5-45 yrs	9-50yrs
4	Mean age	27yrs, (SD11.47)	24.6 yrs, (SD11.17)

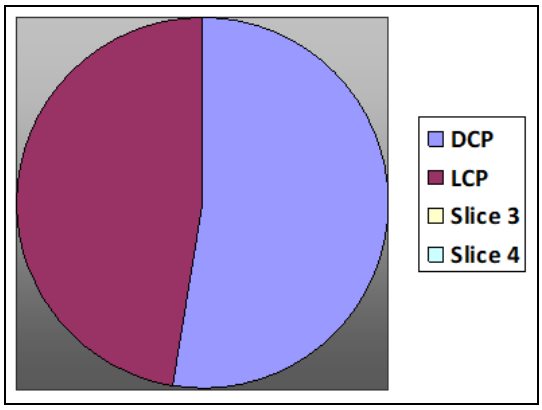

Table 2: The details of fractures in groups (N=48)

S No	Types of Fractures	Group I (DCP)	Group II (LCP)
1	Radius	3	8
2	Ulna	6	1
3	Radius and Ulna	15	15
	Total	24	24

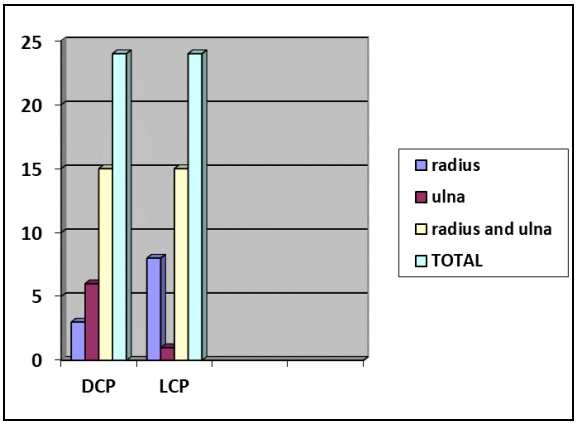

Table 3: Mode of Injury (N=48)

S No	Mode of Injury	Group I (DCP)	Group II (LCP)
1	Road Traffic Accidents	14	11
2	Slip & fall	7	9
3	Sports activities	3	4
	Total	24	24

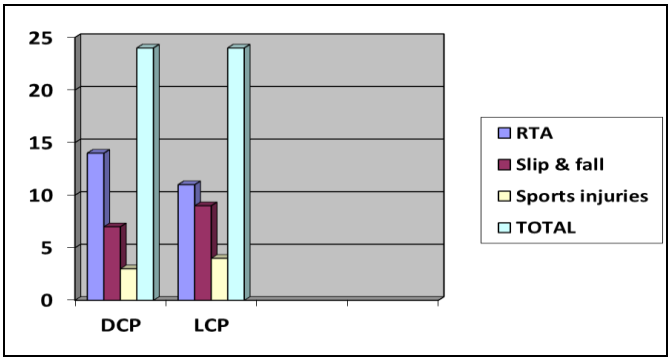

Table 4: Types of Fractures (N=48)

S. No	Type of fracture	Group I (DCP)	Group II (LCP)	Percentage
1	Transverse /oblique fracture	23	22	93.75
2	Comminuted fracture	1	2	6.25
	Total	24	24	

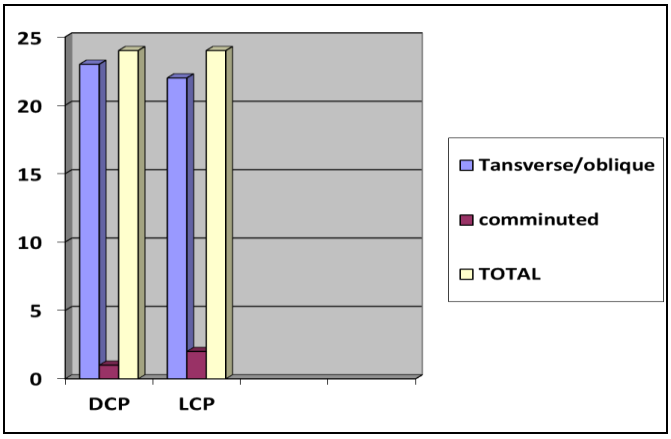

Table 5: Functional outcome of the patients

Outcome	Group I(DCP) (N=24)		Group II (LCP) (N=24)	
	No of cases	Percentage	No of cases	Percentage
Excellent	14	58.33	10	41.66
Satisfactory	7	29.17	12	50.00
Unsatisfactory	3	12.5	2	8.34
Failure	Nil		Nil	

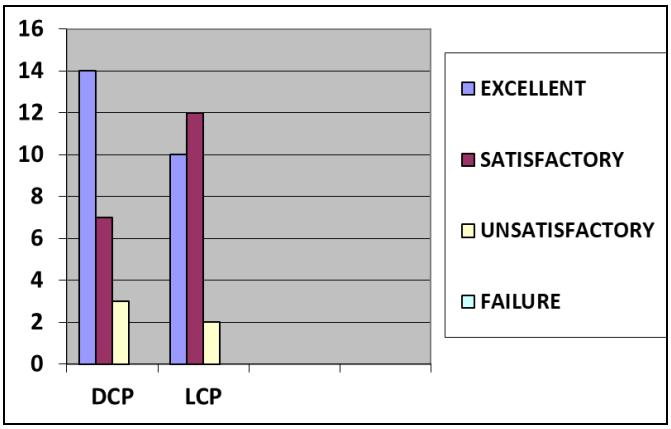

Fig 1: Preoperative and postoperative radiographic image

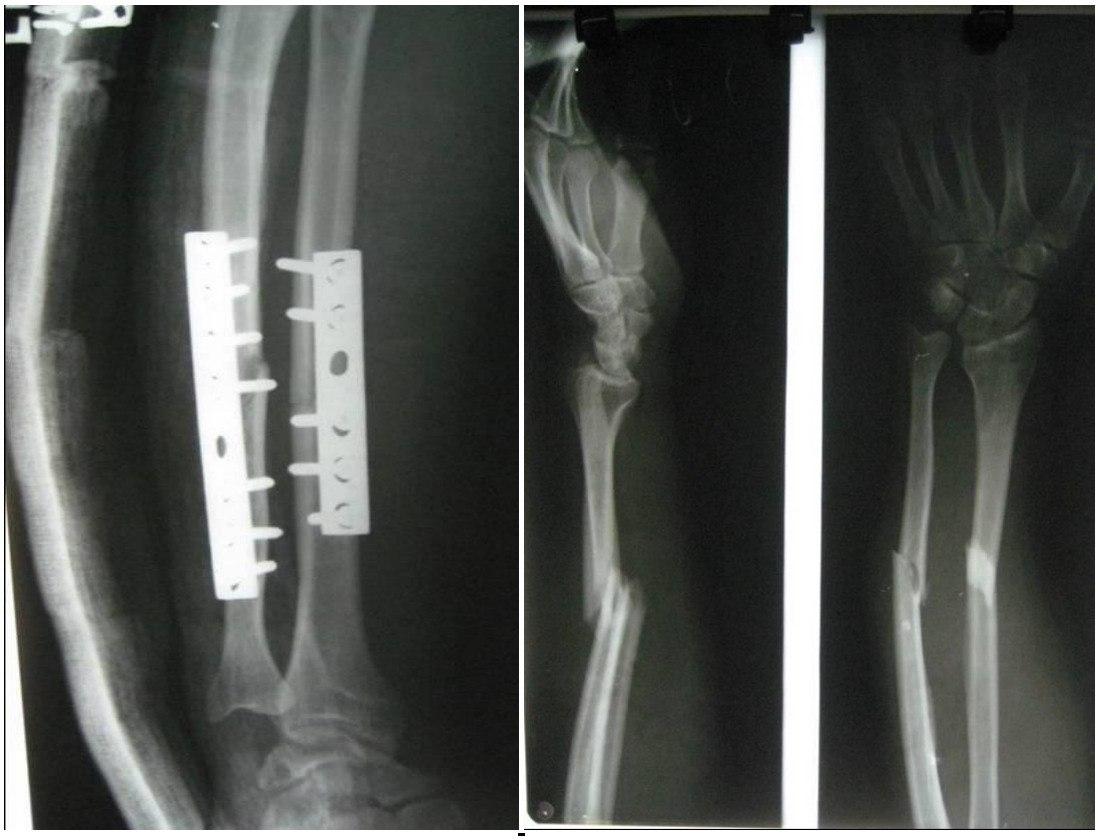

Fig 2: Preoperative and postoperative radiographic image

Discussion

Open reduction and plate fixation have been the most accepted method of treatment of forearm fractures. Anderson and colleagues reported on 244 patients with forearm fractures treated with dynamic compression (DC) plates and found an incidence of union of 97.9% (radius) and 96.3% (ulna) respectively [6]. Time to union was 6.0 to 8.8 weeks. Chapman *et al*. treated forearm fractures in 117 patients with 3.5-mm DCP [7]. They observed a 97% union rate at an average of 12 weeks. The rate of infection was 2.3% in their series. Steven *et al* had 100% union rates in both LCP and DCP [12]. Hertel and collaborators treated 133 patients with forearm fractures and reported a 96.2% union rate before 6 months [8]. They observed three refractures (4.3%) after plate removal at an average of 33.1 months. Leung *et al* in their randomized control trial (RCT) comparing LC-DCP with PC-Fix had found 100% union with a mean period of 17 and 18 weeks, respectively, for closed fractures [13]. In his another series of LCP, there was 100% union, with a mean of 20 weeks [14].

The results of the present study are similar to those reported in the literature for the DCP. In the present study, fracture union rate of 97.43% was observed in DCP group. Delayed union was found in one patient (2.56%). There had been only one incidence of superficial wound Infection (2.56%).

Since the introduction of the LCP in 2001, various papers have dealt with clinical results obtained with this osteosynthesis system. Overall, satisfactory results have been reported for all published studies. The first clinical study, involving internal fixation of 169 fractures in 144 patients was published by Sommer in 2003 [9]. He used LCP in internal fixation of fractures of femur, tibia, humerus and radius.

In 130 fractures (86%), healing took place within the expected period and without complication. In 19 patients, unexpected complications occurred due to incorrect fixation technique, incorrect choice of plate. No purely implant related complications were observed. In a study of internal fixation of forearm fractures using LCP, Leung & Chow has reported fracture union in 30 cases out of 32(union rate 93.75%) [10]. There have been 2 delayed unions (6.25%). Regarding functional outcome, full range of movements has been reported in 74% cases and slight restriction of movement in remaining 26% of cases.

In our study in Gp II (LCP), union rate has been 97.43%. Only one patient had delayed union. Excellent & satisfactory results were observed in 91.67% cases, while 8.34% of patients had significant restriction of movements.

There have been few studies, comparing the results of internal fixation of forearm fractures using DCP and LCP. CT Stevens *et al* carried out a comparative study of plate osteosynthesis using LCP and DCP in 19 fractures [11]. Nine fractures were treated with LCP osteosynthesis and 10 fractures with a DCP. The endpoint was the time to radiographic consolidation. In LCP group the mean time to bony union was 33 weeks (range: 11to 72, SD: 24), whereas in the DC plate group it was 22 weeks (range: 9 to 63, SD: 15.8). In both groups, all fractures which has been compressed healed in a mean of 22 weeks (range: 13-67, SD: 17.9). All fractures without compression healed in a mean of 32weeks (range: 9 to72, SD: 22.8). In our study, the mean union time in Group I (DCP group) was 13.67 weeks (range 8-24 weeks SD 3.67). Delayed union occurred in one patient in this group. In Group II (LCP group), the mean union time was 16.25 weeks (range 12-24weeks SD 3.14).

In both studies, fracture union occurred earlier in DCP group. It appears that fracture union occurs earlier in DCP group, due to less rigid fixation in comparison to LCP. This difference in fracture union time is not statistically significant in our study.

The shorter radiological healing time is probably due to the interval between radiological controls and also due to the fact that in most of our cases, compression was done at the fracture site. There were only three cases in our study in which fracture was comminuted and plate was applied in bridging mode.

Conclusion

In the present study, we evaluated the results of internal fixation of forearm fractures using Locking Compression Plate and Dynamic Compression Plate. There was no statistically significant difference in the mean union time and complications in both groups. Functional outcome in both groups was assessed using Anderson *et al.* criteria and statistically analyzed [6]. There was no significant difference in the functional outcome in Gp I (DCP group) and Gp II (LCP group) ($p>0.05$). Locking compression plate was found to be a safe and effective device in management of diaphyseal fracture of forearm bones. The limitation of this study is small sample size from a single centre hence significant conclusion could not be drawn.

Both fixation devices were equally effective in treating diaphyseal fractures of forearm. Superiority of one technique over other could not be proven in the present study. Locking plate offers the flexibility of being used as a compression plate, as a bridging fixator, or as a system combining both techniques.

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