Comparative study of functional outcome after internal fixation of comminuted fractures of diaphysis of the forearm with locking compression plate and dynamic compression plate

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Abstract

Introduction: Management of fractures of a forearm over time reflects the evolution of modern Orthopaedics. With the introduction of internal fixation, many surgeons reported encouraging results. The locking compression plate (LCP) and Dynamic Compression Plate (DCP) are newer modalities for fracture fixation of both bone forearm fractures. The study aimed to compare functional outcome after internal fixation of comminuted fractures of diaphysis of the forearm with LCP and DCP.

Methodology: It is a prospective type of comparative study involving 30 patients attended orthopedic casualty due to fractures of diaphysis of the forearm. After primary emergency management, a splint was applied; a radiological examination of the affected limb was carried to assess the fracture type. Alternate patients are fixed with LCP and DCP randomization. All patients were personally examined at follow up on the second, fourth, sixth month, and one year. The functional and radiographic results were recorded according to Anderson et al. criteria. Handgrip assessed and compared to the opposite limb.

Results: Our study reports that younger patients have shown statistically significant good results compared to older patients (p-value-0.013). Prognosis with sex and type of fracture was not statistically significant. Early fixation gives good result, and it is statistically significant (p-value- 0.008). Even though clinically LCP gives better results compared to DCP it is not statistically significant in single fracture (p-value-0.06), but LCP gives better results in both bones forearm, and it is statistically significant (p-value-0.034). The present study had a union rate of 96.66%, with a mean time of union in the LCP group was found to be lesser in comparison to DCP group. All both bones fractures treated with LCP showed callus formation, and 75% of both bones treated with DCP showed callus formation, and it is statistically significant (p-value-0.05). Overall, the patients were satisfied with the outcome in both the groups.

Conclusion: LCP is an effective treatment option for fractures of both bones of the forearm. The present study LCP gives better results in comminuted both bones forearm diaphyseal fractures in comparison to DCP.

Keywords: Locking compression plate, Dynamic compression plate, Forearm fracture, Internal fixation.

Introduction

Forearm fractures can be regarded as articular fractures as slight deviations in the spatial orientation of the radius and ulna will significantly decrease the forearm's rotational amplitude and thereby impair the positioning and function of the hand. Thus, the management of these fractures and their associated injuries deserve special attention as their treatment is not the same as the treatment of other diaphyseal fractures. Imperfect treatment of fractures of the radius and ulna diaphyses leads to a loss of motion as well as muscle imbalance and poor hand function. Several studies presented that, plate osteosynthesis provides a good treatment option which has a very predictable outcome.¹ However, it is important to realize that the choice of implant is not the only parameter that governs the outcome. According to AO documentation, 10-14% all fractures recorded occurred in the forearm.² Fractures of the forearm bones may result in severe loss of function unless adequately treated. Severe loss of function may result in comminuted fractures even though adequate healing of the fractures occurs.

In addition to regaining length, apposition, and axial alignment, achieving normal rotational alignment is necessary if a good range of pronation and supination is to be restored or best restoration of normal function. The rigidity of fixation should be sufficient so that postoperative cast immobilization is not essential Plate fixation is the most accepted fixation method. Further developments in plate

fixation led to the concept of internal fixation with bridging plates for the treatment of diaphyseal fractures. In contrast to conventional internal fixation, then, this form of internal fixation yields only relative stability and the secondary bone healing with callus formation is thus no longer an undesirable side-effect, but rather the object of treatment.³ Given this, the term biological plate osteosynthesis has been introduced for bridging internal fixation. Locking compression plate was devised by combining features of Limited contact DCP (LC DCP) and Point contact fixator. Each of the screw holes allows insertion of a conventional screw or a locking head screw, as it has features of both a smooth sliding compression hole and a threaded locking hole. Although LCPs have theoretical advantages, clinicians are responsible for evaluating their efficacy through wellplanned trials and accurate documentation. We aimed to evaluate the use of LCPs in diaphyseal comminuted forearm fractures over the ordinary DCPs by comparing the functional outcome.

Methodology

We conducted a prospective study on 30 patients who attended orthopedic casualty due to fractures of diaphysis of the forearm at the department of orthopedics, MCH Calicut. The study was carried after obtaining ethical clearance from the institutional ethics committee. The proforma was made, the data such as age, sex, mechanism of injury, type of fracture were noted from the records.

Inclusion criteria

Patients between the ages 20 and 60 of both sexes with fresh fractures which are Grade 1 and grade 2 open fractures in Gustilo Anderson classification or Group B1, B2 and B3 fractures in AO classification were included in this study.

Exclusion criteria

Patient who had a Pathological fracture, associated fractures in same limb or Polytrauma, Grade 3 open fractures in Gustilo Anderson classification or AO types other than B1, B2, B3 were excluded from the study.

On arrival of the patient in the casualty room, Primary emergency management was carried out. Immediately after the admission, the patients are given long arm slab for temporary immobilization. The distal neurocirculatory status of the limb was carefully assessed both before and after application of the splint. In term of the management of open fractures, initial irrigation and debridement, intravenous antibiotics, were done routinely. After applying the splint, a radiological examination of the affected limb to assess the fracture type was done. Alternate patients are fixed with LCP and DCP randomization.

Pre-Operative management were carried out before surgery. The fracture was assessed using radiographs, and proper implants were selected, and the implants were autoclaved and kept ready for surgery. Patient was anesthetized using G.A/ supraclavicular or axillary nerve Block. Radius and Ulna are approached through separate incisions. In supine position Volar Henry's approach for Radius, fracture site identified, soft tissue attachment to the fragments retained as possible. In non-anatomical reductions, the main fragments are adapted but not compressed, and no precise anatomical reduction of fragments is achieved and fixed with 3.5 LCP /DCP in bridging plate method wound closed after attaining hemostasis. Subcutaneous approach for ulna fracture site identified, and fixed with 3.5 mm LCP/ DCP as for radius wound closed after attaining hemostasis.

All patients were personally examined at follow-ups on second, fourth, sixth month, and one year. The functional and radiographic results were recorded according to Anderson et al. criteria.⁴ Functional grading was made depending upon restriction of supination/pronation and wrist palmar flexion/dorsiflexion restriction. The radiological

criterion for fracture healing is periosteal bridging callus or trabeculation extending fracture site. A fracture that had healed at six months is classified as a union; fracture healed after six months without additional operative procedure is called delayed union and those fail to unite after six months or required additional operative procedure is called nonunion. Handgrip assessed and compared to the opposite limb.

Result

The youngest patient was 21 years old, and the oldest was 65 years old. The average age was 41.3 years. The average age for male patients was 36.77 years, and that of the female patient was 49.16 years. There were 17 patients in the 20-40 age group and 13 patients in the above 40 age group. In the final evaluation of 30 patients, in the age group of 20-40 years, there were 14 excellent results, three satisfactory and no unsatisfactory and failure results. In the age group of >40years, there was 4 excellent and 3 satisfactory results, 5 unsatisfactory and one failure results. Younger patients have good results compared to older patients, and that is statistically significant (p-value-0.013) (Table 1). Out of 30 patients, 18(60%) were males, and 12 (40%) were females. Of the 18 males, 10 got excellent results, 3 satisfactory, 4 unsatisfactory, and 1 failure. Of the 12 females, 8 got an excellent result, there were 3 satisfactory, 1 unsatisfactory, and no failures and sex with prognosis are not statistically significant (Table 1).

There were 4 patients who had an ulnar fracture, 8 patients had radius fracture, and 18 patients had both bones fracture. In the final evaluation, there were 2 excellent results, 2 satisfactory and no unsatisfactory and failure results in the Ulnar group. In the Radius group, there was 5 excellent and 2 satisfactory result, 1 unsatisfactory, and no failure results. In both bones group, there was 11 excellent and 2 satisfactory results, 4 unsatisfactory and one failure results (Table 2). The interval between injury and surgery varied between a few hrs to 20 days with a mean of 6 days. Out of the 16 fractures treated within 24 hrs, 13 had excellent and 3 had satisfactory results. In the fractures fixed after 24 hrs there were 14 patients, out of which 5 had excellent, 3 had satisfactory and 5 had unsatisfactory results and one failure (Table 2).

Table 1: Association of prognosis with age and sex

Prognosis		Prognosis	with Age	Prognosis with Sex				
	20-40		>40		Male		Female	
	Frequency	%	Frequency %		Frequency	%	Frequency	%
Excellent	14	82.36	4	30.76	12	66.67	6	50
Satisfactory	3	17.64	3	23.09	3	16.66	3	25
Unsatisfactory	0	0	5	38.46	2	11.11	3	25
Failure	0	0	1	7.69	1	5.56	0	0
Total	17	100	13	100	18	100	12	100

Prognosis	Progn	Type of fractur	Prognosis with time delay					
	Single bone		Both bones		<1day		>1day	
	Frequency	%	Frequency %		Frequency	%	Frequency	%
Excellent	7	58.34	11	61.11	13	50	5	0
Satisfactory	4	33.33	2	11.11	3	25	3	25
Unsatisfactory	1	8.33	4	22.22	0	25	5	50
Failure	0	0	1	5.56	0	0	1	25
Total	12	100	18	100	16	100	14	100

Table 2. Association of	nrognosis y	with type of	fracture and	l time delav
Table 2. Association of	prognosis	with type of	macture and	i unie uelay

Out of 30 cases, 16 cases were treated with DCP, and 14 cases were treated by using LCP. Out of 18 cases of both bones forearm, 10 cases were treated with DCP, and 8 cases were treated by using LCP In the final evaluation, there were 18 (60%) excellent results, 6 (20%) satisfactory, 5 (17%) unsatisfactory and one (3%) failure results. Out of 16 cases were treated with DCP, 8 were excellent, 3 were satisfactory, 4were unsatisfactory and one failure. Among

14 patients who were treated with LCP, 10 had excellent result 3 had satisfactory, 1had unsatisfactory, NO failures. Out of 10 cases were treated with DCP in both bones forearm, 3were excellent, 2 were satisfactory, 4 were unsatisfactory and one failure. Among 8 patients who were treated with LCP, all patients had an excellent result (Table 3).

Table 3: Association of prognosis with type of implant

Prognosis	Progn	osis with	Type of implar	Prognosis with Type of implant in both				
			bones fracture					
	DCP	1	LCP		DCP		LCP	
	Frequency	%	Frequency	Frequency %		%	Frequency	%
Excellent	8	50	10	71.42	5	50	6	75
Satisfactory	3	18.75	3	21.42	0	0	2	25
Unsatisfactory	4	25	1	7.16	4	40	0	0
Failure	1	6.25	0	0	1	10	0	0
Total	16	100	14	100	10	100	8	100

The present study had a union rate of 96.66%, with 5 delayed union in the DCP group and 2 in the LCP group which united in due course (Table 4). There is one nonunion in DCP group which required refixation later. The mean time of union (21.92 weeks, range 18–32 weeks) in the LCP group was found to be lesser in comparison to DCP group (25weeks, range 21-31weeks). In both bones forearm treated with LCP, all fractures are united.

Prognosis	Туре	nt with union	Type of implant with union in both bones fracture					
	DCP LCP			Р	DCP		LCP	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Union	10	62.50	12	85.71	5	50	8	100
Delayed union	5	31.25	2	14.28	4	40	0	00
Non Union	1	6.25	0	0	1	10	0	00
Total	16	100	14	100	10	100	8	100

Table 4: Type of implant with union

All the fractures in the study are fixed with non anatomical reduction. The amount of callus formed at the fracture site was assessed using the criteria of Leung et al.³⁶ All of the forearms in the LCP group healed with radiological evidence of callus formation of which 85.71% (n=12) showed abundant callus formation, 14.29% (n=2) showed moderate callus, In the DCP group, 75% (n=12) of the forearms show callus formation and, 25% (n=4) did not show any callus (Table 5). 12.5% (n=2) showed minimal callus, 50% (n=8) showed moderate callus and 12.5% (n=2) had abundant callus. The two groups were found to differ significantly (P=0.005) when compared concerning the number of forearms that healed with abundant or moderate callus and those that healed with minimal or no callus radiologically.

Prognosis		ormation		Callus for	mation in	nation in both bones forearm			
	DCP		LCP		DCP		LCP		
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	
Nil	3	18.75	1	7.14	2	20	1	12.5	
Minimal	2	12.50	0	0	2	20	0	0	
Moderate	7	43.75	3	21.42	4	40	1	12.5	
Abundant	4	25	10	71.44	2	20	6	75	
Total	16	100	14	100	10	100	8	100	

Table 5: Type of implant with callus formation

All both bones fractures treated with LCP showed callus formation, and 75% of both bones treated with DCP showed callus formation, and it is statistically significant (p-value-0.05). The mean ranges of wrist joint and pronation–supination movements in the LCP group were 143.12, and 141.25degrees, respectively, while they were 134.71, and 130.13degrees, respectively, for the DCP group. The two groups were significant concerning these range of movements (P=0.013). The mean ranges of wrist joint and pronation–supination movements in the LCP group in both bones forearm were 143.75, and 142.5degrees, respectively, while they were 132.77, and 124.4degrees, respectively, for the DCP group. The two groups were significant concerning these range of movements (P=0.011). The grip

strength of the involved side ranged from 80 to 100% of that of the contralateral side in the LCP group and from 60 to 100%, in the DCP group. The two groups reveal significant variation concerning the grip strength (P=0.022).

The DASH questionnaire was used to assess the outcome subjectively. The score was seen to be higher in patients who did not regain their full range of motions at the wrist and forearm. Overall, the patients were satisfied with the outcome in both the groups. The DASH scoring was performed from 6 months onward. The score at the latest follow up was considered. The raw scores ranged from 0 to 30.6 in the LCP group and from 0 to 54.6 in the DCP group. Three patients had pain on load-bearing in the final follow up. We did not remove implants during our study.



Fig. 1: LCP on Ulna (A-Initial x ray, B- After fixation, C- After 6 months)



Fig. 2: DCP on Both bone fracture (A-Initial x ray, B- After fixation, C- After 6 months)



Fig. 3: LCP on both bone fracture (A-Initial x-ray, B- After fixation, C- After 6 months)

Discussion

Open reduction and plate fixation has been the standard treatment of adult diaphyseal forearm fracture.⁵ Locked plates the "internal-external fixators," does not rely on the 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, thereby leading to superior bone healing and minimal complications. Atsunori et al. had stated that LCP is now considered to be superior to the conventional plating system in the treatment of forearm fracture.⁶ In the final evaluation, there were 24 (80%) excellent results, or satisfactory, 5 (17%) unsatisfactory and one (3%) failure results. Our study has functional results comparable to Anderson et al. and Chapman et al.^{4,7}

Functional result is significantly better for LCP than DCP in both bones forearm group, but the study is not able to statistically prove better results of LCP over DCP in total samples even though clinically better results obtained. There were 8(27%) open fractures compared to 38% in Chapman et al. and 11% in Anderson et al.^{4,7}

The present study had a union rate of 96.66%, with five delayed union in the DCP group and 2 in the LCP group which united in due course. The mean time of union (21.92 weeks, range 18–32 weeks) in the LCP group was found to be lesser in comparison to DCP group (25 weeks, range 21-31 weeks) which is comparable to Leung et al., Anderson et al., Chapman et al.⁴⁻⁷

In our study fractures fixed with LCP united early compared DCP. There are no delayed union or nonunion in both bones forearm fixed with LCP In non-anatomical reduction plate was applied in a bridging mode, or a conventional mode without compression, or where small comminuted fragments are not precisely adapted for fear of avascularity. Since callus formation was found to be more in the non-anatomically reduced forearms, we agree with Leung that it is the quality of reduction and control of stability in LCP which determine the type and speed of healing.⁵ It also supports Wagner's view that the locked internal fixator technique allows but does not require precise reduction and that it gives priority to biology over mechanics.⁸

Our study showed 86.66% callus formations and it is comparable with KC Saikia et al.⁹ The two groups were found to differ significantly concerning callus formation, which highlights the biologic nature of LCP plating.

The mean ranges of wrist joint and pronation– supination movements in the LCP group were 143.12, and 141.25degrees respectively, while they were 134.71, and 130.13degrees, respectively, for the DCP group. The two groups were significant concerning these range of movements (P=0.013). This was comparable with the study by KC Saikia et al.⁹ Movements showed significant difference in both bones of the forearm also The grip strength of the involved side ranged from 80 to 100% of that of the contralateral side in the LCP group and from 60 to 100%, in the DCP group.

The two groups reveal significant variation concerning the grip strength (P=0.022). The grip strength of the involved side ranged from 80 to 100% of that of the contralateral side in the LCP group; results are comparable to KC Saikia et al.9 Three patients had pain on load-bearing at one year. The DASH scores ranged from 0 to 30.6 in the LCP group and from 0 to 54.6 in the DCP group. The raw scores ranged from 0 to 22.32 in the LCP group and from 0 to 44.44 in the LC-DCP group in K.C Saikia et al., results are comparable for LCP.⁹ Thus, the results of the present study was similar with the previous reported studies in terms of functional outcome in a few studies.^{4,5,7} Functional outcome and complications in comparison to few studies are inferior because all our cases are comminuted fractures.^{5,7} LCP gives better results in comminuted both bones forearm fractures in comparison to DCP even though study cannot prove better results overall forearm fractures, results are better in young patients in whom fixation was done early. LCP gives early union better callus formation early mobilization and early functional return.

Conclusion

LC plating is an effective treatment option for fractures of both bones of the forearm. The outcome is determined by using the proper principles of plating. The present study Locking compression plate gives better results in comminuted both bones forearm diaphyseal fractures in comparison to Dynamic compression plate even though study cannot prove better results overall forearm fractures, Results are better in young patients in whom fixation was done early.

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Conflict of interest

None declared

Ethical approval

The study was approved by the Institutional Ethics Committee.

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