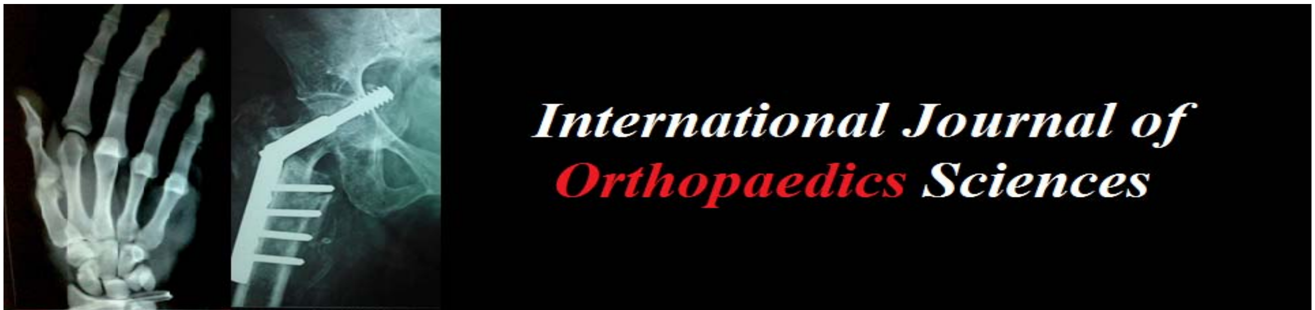

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Surgical management of fracture both bones forearm in adults using LC-DCP

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Abstract
Background: Fractures of both bone of the forearm are relatively common injuries which can challenge the treating orthopaedican. Healing occurs reliably after closed treatment but malunion, with resultant decreased rotation of the forearm is common and has been associated with poor results [1]. Rotation of the forearm is a complex interaction between the radius and ulna and restoration of this movement depends on both on accurate reduction of fractures, this is achieved by ORIF using LC-DCP. [3]
The "Limited Contact Dynamic Compression Plate", was developed by Perren S. M. et to release the new concept of biological internal fixation. Grooves on the undersurface of the LC-DCP improved blood circulation. There is decreased damage to contact between plate and bone. It also allows for a small bone bridge beneath the plate at the most critical area, which is otherwise weak due to a stress concentration effect. In addition, there is more even distribution of the plate than in conventional plates. This study is undertaken to assess the results of diaphyseal fractures of BBFA using LCDCP to study the advantages and its complications.
Materials and Methods: Patients who are admitted in Adichunchanagiri Institute of Medical Sciences are taken for study after obtaining their consent. This is prospective study from May 2013 to May 2016.
Results: This study consists of 50 cases of fracture Both Bone Forearm Fractures. All cases were openly reduced and internally fixed with 3.5 mm LCDCP. Fracture was common in second and third decade with average age of 43 years (18-64 years). In our study, male preponderance was found with 74% males and 26% female patients. Side affected 32 (64%) Left side and 18 patients (36%) right side. Mode of injury in the present study, RTA (60%), fall (30%) and assault (10%). An average time for union was 17 weeks Results were evaluated by Andersons scoring system. In present study, we had 45 patients (90%) with excellent results, 4 case (8%) as satisfactory and 1 case (2%) as failure which required refixation. In the present study there was 3 case (6%) of superficial infection, 1 case (2%) of non-union of radius which required refixation with bone grafting.
Conclusion: LC-DCP can be considered the best mode of treatment for closed diaphyseal fractures of both bones forearm.

Keywords: Both bones forearm, diaphyseal fractures, limited contact dynamic compression plate, Andersons scoring system

Introduction
The forearm has a complex architecture consisting of two mobile relatively parallel bones that provide a stable link between the elbow and the wrist and serve as the origin of several muscles inserting on the hand. As a result, fracture of both bones forearm present unique problems not encountered with fractures of the shafts of other long bones. Restoration of forearm rotation, elbow and wrist motion and grip strength has been shown to be facilitated by anatomic reduction and internal fixation of these fractures [1].
The forearm rotation is the most important contribution to the rotational mobility of upper limb. The two-bone unit with its proximal and distal radio-ulnar joints, and its rotational axis connecting the centres of the two, have been viewed as a single bicondylar joint. When combined with rotational motion of the shoulder, forearm rotation permits the hand to be positioned through an entire 360o arc of motion. With the shoulder fully abducted, nearly all of the rotational motion of the upper limb occurs through the forearm. Activities such as, accepting objects in the palm of the hand require nearly full forearm supination while many other functional tasks require some degree of pronation [2].

The interosseous membrane**:** which is considered to be better described as a ligament, also contributes to the longitudinal stability of the forearm. *The central band* contributes to the axial stability of the forearm, while *the dorsal oblique band* adds to the stability of proximal radioulnar joint and *the distal membranous portion* functions as a secondary stabilizer of the distal radioulnar joint [2].

The radial bow should be maintained for the good functional outcome. It is important to regain the length of the bones, good opposition and alignment without any malrotation. In the normal forearm, the maximal radial bow is reported to be about 15 mm and located at 60% of the radial length from the distal end. For the rotation of the forearm to be at least 80% of the opposite side, the normal radial bow should not differ more than 1.5 mm and its location should not differ by more than 9% from that of the normal arm [3].

Stabilization with internal plate fixation following fracture of both bones of the forearm restores nearly normal anatomy and motion [4]. However, a moderate reduction in the strength of the forearm, wrist and grip should be expected.

The plates most widely used for internal fixation of forearm fractures are the 3.5 dynamic compression plate (DCP) and the 3.5mm Limited Contact Dynamic Compression Plate (Lc-Dcp). In comparison to the DCP, the contact area between the bone and the LC-DCP is reduced by about 50%. This theoretically improves the blood supply to the underlying bone cortex and lessens the risk of partial bone necrosis. This in turn may be associated with improved healing and lower infection rates [5, 23].

In the present study, fifty cases of diaphyseal fracture of both bone forearm are treated surgically with LC-DCP in Adichunchanagiri institute of medical sciences, B.G. Nagara. With Andersons *et al* scoring system the functional outcome was evaluated using the Range of elbow and wrist movement and Union of the fracture. The forearm rotation and wrist and elbow movements, time taken for union, the rate of union and the complications are studied.

Objectives of the Study

- To study the functional outcome of plating of diaphyseal fracture of BBFA with LC-DCP in adults, using Andersons *et al* scoring system.
- To study the biomechanics of forearm fracture and forearm kinesiology and its relevance in better functional outcome of treating forearm fractures.
- To study the age and sex distribution of patients with fracture of BBFA in adults
- To study the advantages and complications of LC-DCP plating of fracture of BBFA.
- Hypothesis: The LC-DCP plating of fracture of BBFA in adults is associated with good bone healing and the complication rates are fewer.

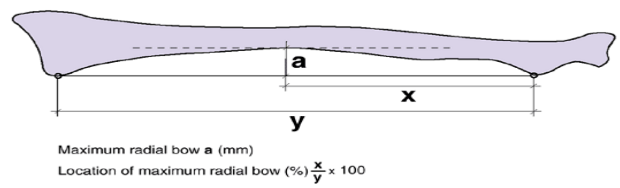
Surgical Anatomy of the Forearm

Radius

The radius is the lateral bone of the forearm. It has expanded proximal and distal ends; the distal is much the broader. The shaft widens rapidly towards its distal end, is convex laterally and concave anteriorly in its distal part. The proximal end includes a head, neck and tuberosity. The head is discoid, its proximal surface a shallow cup for the humeral capitulum. Its smooth articular periphery is vertically deepest medially, where it contacts the ulnar radial notch. The shaft has a lateral convexity, and is triangular in section. The interosseous membrane is attached to its distal three-fourths, and connects the radius to the ulna. The distal end is the widest part. It is four-sided in section [3]. The radius ossifies from three centres. One appears centrally in the shaft in the eighth week of fetal life, and the others appear in each end [6].

The maximum radial bow can be measured by standard lateral radiograph with forearm in neutral rotation. A reference line is drawn from the tip of the bicipital tuberosity to the ulnars most aspect of the distal radius. The maximum radial bow is measured as the number of millimeters along a perpendicular line to the reference line drawn primarily.

It is measured as the percentage distance from the tip of bicipital tuberosity to the point of the apex of maximum radial bow along the length of reference line (i.e., x/y x 100). Failure to restore the parameters within approximately 4% of the opposite was associated with a loss of 20% or more of forearm rotation.



Measurement of maximal radial bow by the method of Schemitsch and Richards

Table 1: Relationship of range of motion and maximal radial bow

Range of Motion (ROM)	Maximum Radial Bow	Location of Maximum Radial Bow
Normal	15.3 Â± 0.3 mm	59.9 Â± 0.7%
>80% of normal ROM	15.3 Â± 1.5 mm	59.9 Â± 4.3%
<80% of normal ROM	15.3 Â± 2.8 mm	59.9 Â± 8.9%

ULNA

The ulna is medial to the radius in the supinated forearm. Its proximal end is a massive hook which is concave forwards. The lateral border of the shaft is a sharp interosseous crest. The bone diminishes progressively from its proximal mass throughout almost its whole length, but at its distal end expands into a small rounded head and styloid process. The proximal end has large olecranon and coronoid processes and trochlear and radial notches which articulate with the humerus and radius. The shaft is triangular in section in its proximal three-fourths, but distally is almost cylindrical. It has anterior, posterior and medial surfaces and interosseous, posterior and anterior borders [3]. The distal end is slightly expanded and has a head and styloid process. The head is visible in pronation on the posteromedial carpal aspect, and can be gripped when the supinated hand is flexed.

The Radio-Ulnar Articulation

The radius and ulna are joined to each other at the superior and inferior radio- ulnar joints. The two bones are also connected by the interosseous membrane, which is sometimes said to constitute a middle radioulnar joint.

Superior radio ulnar joint**:** It is pivot type of synovial joint. The essential structure is the annular ligament, which imprisons the head of radius. The annular ligament is attached to the anterior and posterior margins of radial notch of ulna and has no attachment to radius. Superiorly, it blends with the capsule at the lower margin of the cylindrical articular surfaces.

Inferior radioulnar joint: It is closed distally by a triangular fibrocartilage, which is attached to its base to the ulnar notch of radius and by its apex to a fossa at the base of ulnar styloid.

Interosseous membrane: This connects the borders of two bones. Its fibers run from radius down to the ulna at an oblique angle and are supposed to have an effect in transmitting thrust from the wrist to the elbow via lower end of radius to upper end of ulna and to the humerus. It provides attachment to many muscles of forearm. Interosseous membrane becomes taut while forearm is in pronation and lax while in supination.**7**

Mechanism of Injury

Of the many mechanisms of injury that cause fractures of the radius and ulna, a direct blow is the most common. These are not infrequently associated with road traffic accidents and result in high-energy trauma associated with significant soft tissue damage and with a high incidence of open fractures.

Other direct blows occur in fights in which the defender uses the forearm for protection. A direct blow under these circumstances may cause a fracture of both bones of the forearm but May also cause an isolated ulnar fracture, often called a night stick fracture, or a Monteggia fracture dislocation.

Gunshot injuries may also cause high energy trauma to the forearm. These cause open fractures which are commonly associated with significant bone loss, major soft tissue damage, and injury to the neurovascular structure.

Less frequently fractures of the forearm may result from falls from a height or from sports injuries. However, the force required to cause fractures of the diaphysis of the radius and ulna is much higher than that required to cause a distal radial fracture. Consequently, forearm fractures in sportsmen and women are uncommon and if diagnosed the surgeon should always suspect the possibility of associated ligamentous and soft tissue damage [3].

In fracture of the shaft of radius at the junction of the upper and middle third, the proximal fragment is supinated, while the distal fragment is pronated. There may be from 90 to 1800 of rotational displacement. These fractures are therefore immobilized with hand and forearm supinated. Fragment is supinated, while the distal fragment is pronated. There may be from 90 to 1800 of rotational displacement. These fractures are therefore immobilized with hand and forearm supinated.

If the fracture is at or below the middle third of the bone, the proximal fragment has both supinator and pronator muscles attatched to it. Hence the forearm fracture immobilized with hand and forearm in mid-prone position [8].

Methodology

This study includes treatment of 50 cases of fracture of both bones of forearm by open reduction and internal fixation with 3.5 mm LC-DCP between May 2013 to May 2016 at Adichunchanagiri institute of medical sciences, B.G. Nagar.

This is a prospective time bound study. Sample size is 50 patients.

Evaluation

The results are evaluated with Anderson's criteria for evaluation of forearm bones fracture. The results are compared with previous studies.

Ethical clearance has been obtained from the Ethical Committee of Adichunchanagiri institute of medical sciences, B. G. Nagara.

On admission of the patient, a careful history was elicited from the patient and/or attendants to reveal the mechanism of injury and the severity of trauma. The patients were then assessed clinically to evaluate their general condition and the local injury.

In general condition of the patient the vital signs were recorded. Methodical examination was done to rule out fractures at other sites. Local examination of injured forearm revealed swelling, deformity and loss of function. Any nerve injury was looked for and noted.

Palpation revealed, abnormal mobility, crepitus and shortening of the forearm, distal vascularity was assessed by radial artery pulsations, capillary filling, pallor and paraesthesia at finger tips.

Radiographs of the radius and ulna i.e., anteroposterior and lateral views, were obtained. The elbow and wrist joints were included in each view. The limb was then immobilized in above elbow Plaster of Paris slab with sling.

The patient was taken for surgery after routine investigations and after obtaining fitness for surgery. The investigations are as follows: Hb%, Urine for sugar, FBS, Blood urea, Serum creatinine, ECG and chest x-ray.

Preoperative Planning

- Consent of the patient or relative was taken prior to the surgery.
- A dose of tetanus toxoid and prophylactic antibiotic were given preoperatively.
- After studying the x-ray, fracture was classified and pattern was assessed.
- The length of the plates and screws and instruments required were assesed using x-ray before surgery.
- Preparation of the part was done on the table.

Type of anaesthesia

General anaesthesia was used in 33 cases and brachial block in 17 cases.

Operative procedure

After anaesthesia, part was painted and draped. The radius was approached by Dorsal Thomson/ Volar Henry's approach for proximal radius and mid shaft fractures, Dorsal Thomson approach was preferred for proximal fractures, and for distal radius fractures, Volar Henry's approach was preferred. Ulna was approached directly over the subcutaneous border.

After identifying the fracture ends, periosteum was elevated and fracture ends were cleaned. With the help of reduction clamps fracture was reduced and held in position. The plate was then applied after contouring, if required. For upper third radial fractures, the plate was fixed dorsally, for distal two thirds, the plate was fixed dorsolaterally and for distal radial fractures the plate was fixed on the volar aspect. In ulna fractures plate was applied over the posteromedial surface of ulna [9].

Using the neutral drill guide, the first screw is applied to the fragment, which forms an obtuse angle with the fracture near the plate. The resulting space between the fracture plane and plate undersurface guides the opposite fragment towards the plate. The arrow of the neutral drill guide points towards the fractures. 2.5 mm drill bit is used for drilling a hole through both cortices and with depth gauge appropriate 3.5 mm screw length is determined, 3.5 mm drill tap used before screw insertion [9].

After adaptation of the fragments, a screw hole for axial compression is drilled in the fragment, which forms an acute angle near the plate. Here the load guide is used with the arrow pointing towards the fracture line to be compressed. At this position, a lag screw will be inserted for axial compression.

The lag screw is applied by subsequently over drilling (3.5 mm) the near cortex to create a gliding hole. The lag screw and remaining screws are inserted.

The contour between the plate and the screw head of the eccentrically placed screw moves the screw head towards the center of the plate and thus moves the fragment into the same direction.

In case of porotic, comminuted and/or small bones, long screws and/or a longer plate were used. Once stable fixation is achieved and hemostasis secured meticulously, the wound is closed in layers over a suction drain and sterile dressing is applied.

Postoperative care

The limb was kept elevated for 24 to 48 hours and the patient was instructed to move their fingers and elbow joint. Suction drain was removed after 24 to 48 hours. Wound was inspected after 3 to 4 days postoperatively. Antibiotics and analgesics were given to the patient till the time of suture removal. Suture removed on 10th postoperative day and check X-ray in anteroposterior and lateral views were obtained.

Physiotherapy

A posterior plaster splint was applied for comfort for 2 to 3 days. Patient was encouraged to perform both active and active-assisted range of motion exercises of shoulder and hand. Elbow range of motion, supination and pronation exercises were begun as soon as remission of pain and swelling of forearm permits, usually after 2 to 3 days. Because of rigidity of fixation, rapid return of motion was expected. These isotonic exercises are very much essential for the excellent outcome. Physiotherapy helps in fracture union, as there is increased blood supply and tethering of muscles to the bone and soft tissue contracture is avoided. Thus, physiotherapy with rigid fixation, which gives excellent results.[10]

Follow-up -All the patients were followed up as monthly intervals for first 3 months and evaluation was done based on "Anderson *et al* scoring system" [11]. Elbow movements and wrist movements were noted and the union was assessed radiologically. The fracture was designated as united, when there was presence of periosteal callus bridging the fracture site and trabeculation extending across the fracture line.

Operative Photograph

Instruments

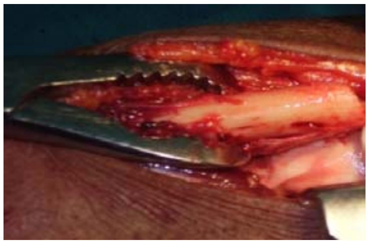
3.5 mm LC-DCP plates

Parts prepared and draped

Volar Henry's approach for radius

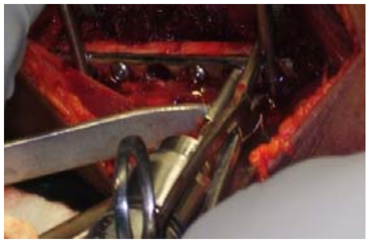
Intermuscular plane dissection

Retraction of the radial artery

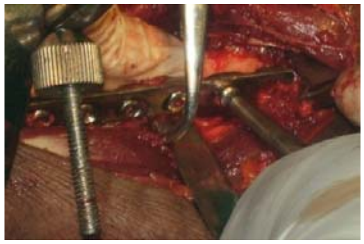


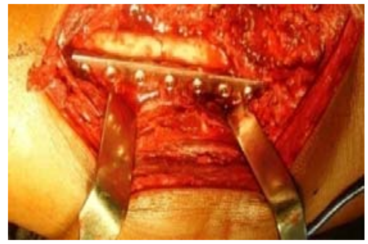
Fractured bone ends

3.5mm LC-DCP plate


2.7 mm drill bit


Tapping using 3.5 mm tap

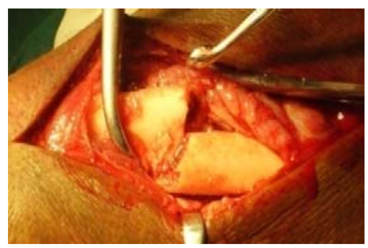

3.5 mm cortical screw


finally tightened screws


Closure of subcutaneous tissue

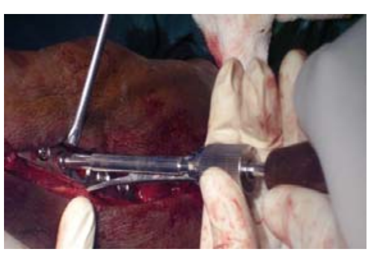

Skin closure

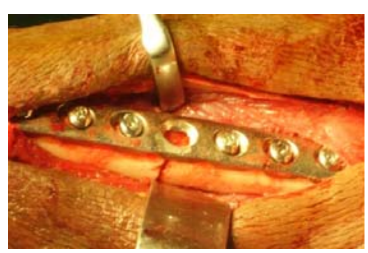

Approach to ulna


Exposure of fracture site


Reduced fracture site


2.7 mm drill bit


Application of 3.5 mm cortical screws


finally tightened screws

Closure of subcutaneous tissues

Skin closure on ulnar site

Results

The present study consists of 50 cases of fracture both bones of the forearm. All the cases were openly reduced and internally fixed with 3.5mm LC-DCP. The study period was from May 2013 to May 2016.

Table 2: Age Distribution

Age	No. of Patient's	Percentage
18 – 25	06	12
26 – 35	14	28
36 – 45	18	36
46 – 55	08	16
56 – 65	04	08
Total	50	100

Table 3: Sex distribution

Sex	No. of Patient's	Percentage
Male	37	74
Female	13	26
Total	50	100

Table 4: Side affected

Side affected	No. of Patient's	Percentage
Left	32	64
Right	18	36
Total	50	100

Table 5: Mode of injury

Mode of injury	No. of Patient's	Percentage
RTA	30	60
Self-fall	15	30
Assault	05	10
Total	50	100

Table 6: Level of fracture

Level of injury	No. of Patient's	Percentage
Middle third fractures	32	64
Proximal third fractures	13	26
Lower third fractures	05	10
Total	50	100

Statistics of surgery

33 of the 50 cases were operated under general anesthesia and in other 17 patients brachial block was used. Dorsal Thompson approach for radius was used in 10 patients and volar Henrys approach for radius was used in 40 patients. Ulna was approached subcutaneously. Pneumatic tourniquet was used in all the cases. Follow-up ranged from 5 months to 24 months.

Duration of surgery and tourniquet time

In our study, we noted the duration of surgery ranged from 60 to 95 minutes, with average time of 74.5 minutes. The tourniquet time ranged from 40 to 60 minutes, with average time of 49 minutes.

Duration of fracture union

The fracture was considered as united when there were no subjective complaints, radiologically when the fracture line was not visible. Those fractures, which healed after 6 months without an additional operative procedure was considered as delayed union. Fractures, which did not unite after six months or that needed an additional operative procedure to unite was considered as non-union.

Table 7: Duration of fracture union

Time of union	No. of cases	Percentage
< 4 months (16 weeks)	30	60
4-6 months (16 – 24 weeks)	19	38
6 months - 1 year (24-36 weeks)	1	2
Total	50	100

Table 8: Complications

Complications	No. of cases	Percentage
Superficial infection	03	06
Nonunion of radius	01	02

Criteria for Evaluation of Result

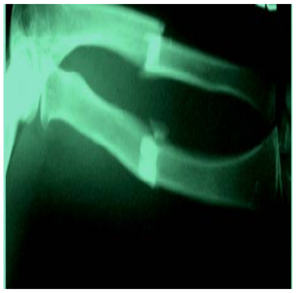
"Anderson" *et al* scoring system

Results	Union	Flexion / Extension at elbow joint	Supination and pronation
Excellent	Present	<100 loss	<25% loss
Satisfactory	Present	<200 loss	<50% loss
Unsatisfactory	Present	>200 loss	>50% loss
Failure	Non union with / without loss of motion		

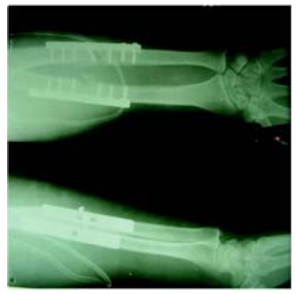
Table 09: Functional Results

Results	No. of cases	Percentage
Excellent	45	90
Satisfactory	4	8
Unsatisfactory	Nil	Nil
Failure (required refixation with bone grafting)	1	2

Clinical Photographs
Case Series 01

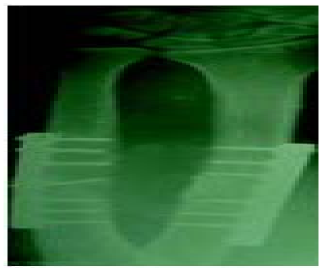


Pre-0p X-ray



Immediate Postoperative X Ray

Follow Up X-ray At 4th Month



Follow Up X-ray At 1st Year

Elbow flexion

Elbow Extension

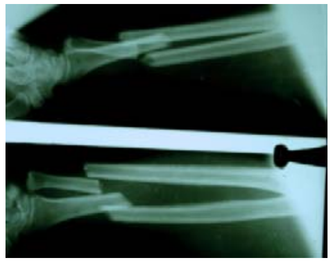
Pronation

Supination

Wrist Dorsiflexion

Wrist Palmar Flexion

Case Series 02



Pre-Operative X-Ray

Post-Operative X-Ray

X-Ray after 4 Month

X-ray after 1 Year

Elbow Flexion

Elbow Extension

Supination

Pronation

Wrist Dorsiflexion

Wrist Palmar Flexion

Discussion

Fracture of both bones of the forearm are relatively common injuries which can challenge the treating physician. Healing occurs relatively 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 post-operative movements. Loss of rotation impedes function of the upper limb and activities of daily living [12].

Compression plate fixation has become the treatment of choice for fractures of both bones of the forearm. Compression plate fixation gives a high rate of union, low rate of complications, and a satisfactory return of rotation of the forearm [12].

As reported by Kurt. P. Droll in 2007 based on his study, plate fixation of diaphyseal fractures of both bones of the forearm using 3.5mm Limited contact Dynamic Compression plate restores nearly normal anatomy and motion even though strength remains an average of 30% less than that of contralateral extremity years after the injury [1].

So, the LC-DCPs are the best implants for diaphyseal fracture of both bones forearm at present. LC-DCPs have got multiple advantages since their interference with the periosteal circulation is less. They give good results. The rate of union is high, osteoporosis and refracture after removal is very low.

The present study was undertaken to determine the efficacy of LC-DCP in the treatment of fractures of both bones of the forearm. A total of 50 patients of fracture both bones of forearm were treated with open reduction and internal fixation using 3.5 mm LC-DCP.

We evaluated our results and compared with those obtained by various other studies utilizing different modalities of treatment. Our analysis is as follows

Age Distribution

Our findings are comparable to the study made by Goldfarb in 2005 who found an average age of 41years [12]. In 1972, Herbert S. Dodge and Gerald W. Cady accounted the average age as 24 years [13]. Berton R. Moed (1986) [14] showed the average age was 22 years [14]. In 1989, Chapman found 33 years as average (13-79) [15]. In 1992, Schemitsch accounted 24 years as average (16-83) [16]. In 2003 an average of 36 years (11-90 years) was found by Frankie Leung and Shew Ping chow [19]. In 2005, Goldfarb found 40 years as average (19-84) [12]. In 2007, Kurt. P. Droll found 43.9 years as average (18-73) [1]. In 2010, Peter kloen found 37 years as average (16-76) [17]. In the study conducted at Adichunchanagiri institute of medical sciences, fracture was common in second and third decade with average age of 43 years (18-64 years).

Table 10

Series	Minimum age(years)	Maximum age(years)	Average age(years)
Goldfarb [12]	19	84	40
Peter kloen [17]	16	76	37
Kurt.P.Droll [1]	18	73	43.9
Herbert Dodge [13]	13	59	24
Michael Chapman [15]	13	79	33
Moed BR [14]	14	65	22
Schemitsch *et al* [16]	16	83	24
Frankie Leung [19]	11	90	36
Present study	18	64	43

Sex distribution

Our study is comparable to study by Peter kloen in 2010. Burwell reported 69.33% were males and 30.67% were females. Herbert Dodge found 89% males and 11% females [13]. Michael Chapman found 78% males and 22% females [15]. William reported 67% males and 33% of females [20]. In 2003, Frankie-Leung series showed 82.6% males and 17.4% females [19] In 2005, Goldfarb found 60.9% males and 39.1% females [12]. In 2007, Kurt.P.Droll found 63%males and 37% females [1]. In 2010, Peter kloen found 74% males and 26% females [17]. In our study, male preponderance with 74% males and 26% female patients, which was comparable to previous studies.

Table 11

Series	Males (%)	Females (%)
Goldfarb [12]	60.9	39.1
Peter kloen [17]	74	26
Kurt.P.Droll [1]	63	37
Herbert Dodge [13]	89	11
Michael Chapman [15]	78	22
William AT[20]	67	33
Frankie Leung [19]	82.6	17.4
Burwell *et al* [18]	69.33	30.67
Present study	74	26

Mode of Injury

Moed BR found RTA (50%), industrial accidents (20%), fall (14%), direct blow (12%) and gunshot injuries (4%) [14]. Thomas Grace *et al* noted RTA (45%) fall, (22%), other miscellaneous types of injuries (33%).Smith found (45%) RTA, (36%) fall and (19%) industrial accidents. In 2005 Goldfarb noted, RTA (56.5%), fall (21.7%) and assault (21.7%) of patients [12]. In 2007 Kurt. P. Droll noted, RTA (55%), fall (26%) and assault (19%) of patients [1]. In 2010 Peter kloen noted, RTA (63%), fall (30%) and assault (7%) of patients [17]. In the present study, RTA (60%), fall (30%) and assault (10%).

Table 12

Series	Accident (%)	Fall	Direct blow/Miscellaneous
Goldfarb [12]	56.5	21.7	21.7
Peter kloen [17]	63	30	7
Kurt. P. Droll [1]	55	26	19
Moed [14]	70	14	16
Grace	45	22	33
Smith	45	36	19
Schemitsch *et al* [16]	34.55	38.18	27.73
Present study	60	30	10

Extremity affected

Burwell HN and Charnley AD 49.33% cases of right forearm fractures and 50.67% cases of left forearm fractures [18]. Chapman MW reported about 55% cases of right forearm fractures and 45% cases of left forearm fractures [15]. Schemitsch reported about 43.63% cases of right forearm fractures and 56.37% cases of left forearm fractures [16]. In 2005 Goldfarb reported about 37.5%cases of right forearm fractures and 62.5% cases of left forearm fractures [12]. In 2007, Kurt. P. Droll reported about 53%cases of right forearm fractures and 45% cases of left forearm fractures [1].

In 2010, Peter kloen reported about 40%cases of right forearm fractures and 60% cases of left forearm fractures [17].

Table 13

Series	Right (%)	Left (%)	Both (%)
Goldfarb [12]	37.5	62.5	8
Peter kloen [17]	40	60	2
Kurt. P. Droll [1]	53	45	_
Burwell HN [18]	49.33	50.67	_
Michael Chapman [15]	55	45	_
Schemitsch *et al* [16]	43.63	56.37	_
Present study	36	64	_

Fracture Anatomy

a. Type of fracture

Chapman noted about 47% were transverse/short oblique, 53% of fractures as comminuted [15]. In our study. about 72.5% were transverse/short oblique, 22.5% of fractures as comminuted and 5% were segmental fractures. The results were not comparable to the previous studies, which can be attributed to low velocity trauma in our country.

Table 14

Series	Transverse/short oblique (%)	Comminuted (%)	Segmental fracture (%)
Chapman [15]	47	53	-
Present study	72.5	22.5	5

b. Level of fracture

In our series, we had 64% of fracture in middle third, 26% proximal and 10% in lower third. In other studies, the incidence of fracture is highest in the middle third and least in the proximal third.

Table 15

Series	Proximal third (%)	Middle third (%)	Distal third (%)
Herbert Dodge [13]	7.14	71.42	21.44
Sarmiento [21]	-	84.6	15.4
Chapman [15]	13	59	28
Present study	26	64	10

Duration of Surgery and Tourniquet Time

The duration of surgery ranged between 60 to 95 minutes, with an average 74.5 minutes. The tourniquet time ranged from 40 to 60 minute, with an average of 49.75 minute. These findings could not be compared to the previous studies, as there was no data available.

Duration of follow-up

Our study is comparable to Chapman series but other series had longer follow- up.

Anderson and Moed followed up for an average of 3 years. In 2005, Goldfarb followed up for an average of 34 months [12]. In 2007, Kurt. P. Droll followed up for an average of 5.4 years [1]. In 2010, Peter kloen followed up for an average of 75 months.

Table 16

Series	Range	Average
Peter kloen [17]	12-315 months	75 months
Kurt.P.Droll [1]	2-13.4 years	5.4years
Goldfarb [12]	11-72 months	34 months
Anderson [11]	4 – 9 years	3 years
Chapman [15]	6 – 48 months	12 months
Moed [14]	12 months – 9 years	3 years
Frankie [19]	14 – 40 months	22 months
Present study	5 – 24 months	12 months

Complications

In the present study there were 3 case of superficial infection which subsided with antibiotics and 1 case of non-union of radius, which required curettage, bone grafting and refixation.

Table 17

Complications	Kurt. P. Droll [1]	Anderson [11]	Chapman [15]	Frankie [19]	Peterkloen [17]	Goldfarb [12]	Present study
Superficial infection	-	2.9%		2%	-	-	6%
Deep infection			2.3%			-	-
Refracture, fracture at the end of the plate and fracture through the compression hole	-	2.9%	2.3%	2%	2.1%	-	-
Back out of screws			2.3%			-	-
Compartment syndrome		-		2%		-	-
Non-union	-	2.9%	-	-		-	2%
Post- interosseous nerve injury	3.3%	2%	1.2%		2.1%	-	-
Injury to other nerves(ulnar nerve, superficial branch of radial nerve)	13%	-		5%	-	-	-
Radio-ulnar synostosis	-	1.2%	1.2%	-	-	-	-
Irritation by hardware	10%	-			-	-	-

Time for Union

Our results are comparable to Frankie's study in 2003, in which he found an average time for union as 17 weeks.19 Time for union varies according to age, general condition, rigidity of fixation and presence of infection. Also interobserver variation is there, regarding time of union. Absence of tenderness at the fracture site and disappearance of fracture line with callus formation is taken as union. In 1975, Anderson found 7.4 weeks as the average union time with 97% union rate [11]. In 1989, Chapman found 12 weeks as average union time with 98% union rate [15]. In 1995, M.D. Mcknee found 10.7 weeks as average union time with 97.3% union rate [22]. In 2003 an average of 17 weeks was found by Frankie Leung and Shew Ping chow with 100% union rate [19]. In 2010, Peter kloen found 28 weeks as average union time with 100% union rate [17].

Anderson's criteria for evaluation of union were taken into account. In our series, we had an average union time of 17 weeks, with the range of 8 to 28 weeks. We had 98% union of both radius and ulna

Table 18

Series	Union times (weeks)	Range (Weeks)	Union (%)
Peter kloen [17]	28	10-84	100
Anderson [11]	7.4	5 – 10	97
Chapman [15]	12	6 – 14	98
Frankie [19]	17	8 – 36	100
Mc Knee [22]	10.7	5 – 18	97.3
Present study	17	8 – 28	98

Functional results

Fracture union and range of movements are the two factors, which affect the functional outcome. So early mobilization prevent soft tissue contracture, muscular tethering and improves the vascularity. Anderson's *et al* scoring system was used as a measure for the functional outcome [11]. In 1975, Anderson *et al* reported about 54 (50.9%) cases as excellent, 37 (34.3%) satisfactory, 12 (11.3%) unsatisfactory and 2 (2.9%) as failure. In 1989, Chapman *et al* reported about 36 (86%) cases as excellent, 3(7%) satisfactory, 1(2%) as unsatisfactory and 2(5%) as failure [15]. In 2003, Frankie Leung reported 98% cases as excellent and 2% as satisfactory results [19]. In 2010 Peter kloen found 29(62%) with excellent results, 8(17%) as satisfactory and 10(21%) cases of unsatisfactory result [17]. In present study, we had 45(90%) with excellent results, 4(8%) as satisfactory and 1(2%) as failure which required refixation and bone grafting.

Table 19

Series	Excellent (%)	Satisfactory (%)	Unsatisfactory (%)	Failure (%)
Peter kloen [17]	62%	17%	21%	-
Anderson [11]	50.9	34.9	11.3	2.9
Chapman [15]	86	7	12	5
Frankie [19]	98	2	-	-
Burwell [18]	77	23.8	10.8	1.4
Present study	90	8	-	2

Conclusion

- Advantages of LC-DCP it facilitates biological fixation of the bone and early bone union. It is easier to apply in comminuted and segmental fracture and short oblique fractures.
- Use of separate incisions for radius and ulna and preservation of the natural curves of radius will lesser the rate of complication.
- Rigid fixation of fractures after perfect anatomical reduction with 3.5 mm LC-DCP and screws allows immediate mobilization.
- A minimum of 6 cortices has to be fixed in each fracture fragment and the nearest screw to the fracture line should be atleast 1 cm away.
- It minimizes vascular damage to the plated bone segment. It should lead to more versatile and efficient application of internal fixation.
- The special design of the plate does not interfere with periosteal circulation to the extent the DCP does so, early union takes place and postoperative osteoporosis does not occur.
- A postoperative plaster is seldom required for uncomplicated fractures and early return to light work is possible.
- It gives excellent functional results in the majority of patients.
- Complication after a well-performed surgery are minor and easily correctable.

Until newer implants are devised and extensively assessed as the versatile LC-DCP these should be used as the implant of choice for all closed displaced diaphyseal fractures of both bones forearm.

Summary

This study has been taken to determine the functional outcome of treating diaphyseal fractures of both bones, forearm with limited contact dynamic compression plate at Adichunchanagiri institute of medical sciences, B.G. Nagara from May 2013 to May 2016

- This is a time-bound prospective study.
- Fifty cases of fractures of both bones forearm were treated by open reduction and internal fixation with 3.5 mm LC-DCP. The follow-up ranged from 5 months to 24 months. Males predominant with left forearm affection more than right. Most of the fractures due to RTA and fall.
- The average age was 43years with fracture being most common in second and third decade comparable to the study made by Goldfarb in 2005.
- Most of the fractures are both bones of forearm were located in the middle third and the fracture pattern transverse/short oblique was commonest.
- 49(98%) patients had sound union in less than 6 months, 1(2%) patient had non-union of radius, which required curettage, bone grafting and refixation.
- The results were based on Anderson *et al* scoring system and in our study, there were 45(90%) patients with excellent results and 4(8%) with satisfactory and 1(2%) case failure due to non-union of radius, which required curettage, bone grafting and refixation.
- Hence the study was satisfactory and LC-DCP can be considered the best mode of treatment for diaphyseal fractures of both bones forearm in adults

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