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## Results of locking compression plate in closed diaphyseal forearm fractures in adults

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### Abstract

**Introduction:** Diaphyseal fracture of ulna and radius present specific problems in Addition to those common to all fractures of shaft of long bones due to their anatomical Characteristics and conservative treatment of these fractures lead to poor functional outcome. Stoffel *et al* showed that plate osteosynthesis with rigid fixation has shown a high complication Rate including delayed or nonunion, infection, hardware failure and most importantly refracture after plate removal, primarily due to necrosis of bone under the plate.

To evaluate results of locking compression plate in closed diaphyseal Forearm fractures in adults.

**Methods:** In prospective study, 22 adults with (38 forearm bones= Radius-20 & Ulna-18) acute closed diaphyseal fractures were treated by open reduction and internal fixation with Locking Compression Plate. Follow up was obtained on all 22 patients. The average duration of follow up was 12 months.

**Results:** The functional outcome was assessed with the grading system of Anderson *et al*.

We had excellent results in all patients.

**Conclusion:** Locking compression plate with a combi-hole provides fixation of fractures in a single implant with vast application according to the situation and useful in wedge or complex or osteoporotic or comminuted fractures because it preserves periosteal blood supply and provides a stable fixation ensuring early mobilisation. Studies having a larger number of fractures treated with different modes are needed to evaluate the outcome of locking compression plate osteosynthesis in forearm bones fractures, but the early results are promising.

**Keywords:** Diaphyseal forearm fractures, locking compression plate, results

### Introduction

Diaphyseal fracture of ulna and radius present specific problems in addition to those common to all fractures of shaft of long bones due to their anatomical characteristics and conservative treatment of these fractures lead to poor functional outcome.

In other long bones some shortening and loss of axial and rotary alignment do not greatly compromise the result. This is not so in case of the forearm. In addition to regaining length, apposition, and axial alignment, achieving normal rotational alignment and the radial bow is necessary to restore good range of supination and pronation of the forearm<sup>[1]</sup>.

However, Stoffel *et al*.<sup>[2]</sup> showed that plate osteosynthesis with rigid fixation has shown a high complication rate including delayed or nonunion, infection, hardware failure and most importantly refracture after plate removal, primarily due to necrosis of bone under the plate.

The locking compression plate is latest in a long sequence of basic improvements in AO technology. The treatment goal was mainly to achieve painless function and “undisturbed” healing<sup>[3]</sup>.

**The LCP can be used in three ways<sup>[4]</sup>:**

- As a **Conventional Plate** using only dynamic compression unit of the combination hole and standard cortex screws,
- As a Pure Internal Fixator using locking head screws only,
- As a Combination of the two above principles.

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The Locked internal fixators do not compress the periosteal blood supply, thereby causing less interference of the fracture hematoma and fracture healing. The elastic fixation of a locked internal fixator acts more like an IM nail or external fixator, allowing for bridge plating with callus formation. Improved fixation and biology lead to better clinical outcome and faster healing<sup>[5]</sup>.

We did prospective study in 38 forearm bones fractures in 22 patients treated by locking compression plate at our center.

### Materials & Methods

From October 2018 to March 2020, 22 adults with acute closed diaphyseal fractures of forearm bones were treated by open reduction and internal fixation with Locking Compression Plate at The Oxford medical college, Bangalore. Follow up was obtained on all 22 patients. Total numbers of fractures fixed were 38 (Radius-20, Ulna-18). The average duration of follow up was 12 months (Range 3-21months).

### Inclusion criteria

Patients above 16 years of age, with closed diaphyseal fractures of forearm bones, fit for surgery & consent to participate in the study.

### Exclusion criteria

Fractures in patients less than 16 years, open fracture of forearm bones, fracture of forearm bones requiring vascular repair, fractures with compartment syndrome needing Fasciotomy and unable to provide consent.

On admission of the patient, they were assessed clinically to evaluate the general condition and the local injury. Neurovascular status assessment was done followed by x-rays in taken in both AP & Lateral views including elbow and wrist joints were taken.

Fractures were stabilized in above elbow POP slab and the medically fit patients were taken for surgery after obtaining informed and signed consent.

An analysis was done in relation to the age and sex distribution, mechanism of injury, location and type of fractures, method of fixation, operative time, fracture healing time, clinical, functional and radiological assessment of end results and complications.

**Age distribution:** In our study, the age distribution was between 16 years and 60 years (average age-32.77yrs).

**Table 1:** Age distribution

Age of the Pts (in Yrs)	No. of Pts
16-20	4
21-30	8
31-40	5
41-50	3
51-60	2

**Sex distribution:** In our study, There were 18 male (81.8%) and 4 female (18.2%) patients in our series.

**Table 2:** Sex distribution

Sex	No. of Patients	Percentage
Male	18	81.8
Female	4	18.2
Total	22	100

**Bones Involved:** Fractures of both forearm bones were seen in 16 patients, isolated ulna in 2 patients and isolated radial fractures in 4 patients.

**Table 3:** Bones Involved

Bones involved	No of patient	Percentage
Isolated radius	4	18
Isolated ulna	2	9
Radius& ulna	16	73
Total	22	100

**Affection of forearm:** Among 22 patients, 5 of the patients had fractures in the right forearm and 17 in the left. Only 22.72 % of fractures were in the dominant upper extremity.

**Table 4:** Affection of forearm

Affection of forearm	Dominant(right)	Non – dominant(left)	Total
Percentage	22.72% (5)	77.28% (17)	100

**Mode of injury:** 12(54.5%) Patients were injured in road traffic accidents, 10 (45.5%) sustained the fractures due to falls and 1 Patient had an associated ACL injury of the right knee.

**Table 5:** Mode of injury

Mode of injury	No. of Patients	Percentage
RTA	12	54.5
Fall	10	45.5
Total	22	100

**Location of fracture:** Depending on the x-ray findings, location of fractures was divided into three groups. To describe the location of each fracture, the shafts of radius and ulna were divided into thirds. The number of fractures in each group was as shown in the table below.

**Table 6:** Location of fracture

Location	Radius	Ulna	Total	Percentage
U/3	3	2	5	13
M/3	12	14	26	68.5
L/3	5	2	7	18.5
Total	20	18	38	100

**Type of fracture:** According to the x-ray findings, types of fractures were divided into: Transverse, Wedge and Comminuted. When the free fragment (butterfly fragment) involved more than one third of the circumference of the shaft of bones at the fracture site, they were considered as comminuted fractures and the number of fractures in each group was as shown in the table below.

**Table 7:** Type of fracture

Type	Radius	Ulna	Total	Percentage
Transverse	4	2	6	15.8
Wedge	9	8	17	44.7
Comminuted	7	8	15	39.5
Total	20	18	38	100

### Methods

**Timing of surgery:** In 4 patients, the surgery was performed on the day of injury and in 18 patients within forty eight hours of injury.

**Anaesthesia:** Regional block (Supraclavicular) was used in 20 patients and General anaesthesia was used in 2 patients where regional block failed.

**Surgical technique:** All cases were operated with pneumatic tourniquet applied after exsanguinations. The radius and ulna were approached through separate incisions.

Ulna was exposed by an incision along its subcutaneous border and plates were placed on the posterior surface. In all radius fractures, fractures were exposed through Henrys<sup>6</sup> extensile approach of the forearm. In the middle thirds, the plate was placed on the lateral surface after contouring the plate (12 fractures). In lower third radial fractures the plate was applied on the volar surface (5 fractures) & No contouring of the plate was needed here.

Fixations of radial and ulnar fractures were accomplished with AO 3.5 mm locking compression plates (LCP). Plates that had 6 to 8 holes were used and depending on fracture pattern, either cortical or locking head screws were used.

Only that surface of the bone on which the plate to be placed was exposed by extraperiosteal dissection. Soft tissue attachment to the comminuted fragments was maintained. The fracture site was cleaned of blood clots and soft tissue after which the fracture was reduced and fixed appropriately.

Among the 38 fractures, 22 fractures (15 comminuted and 7 wedge fractures) fixed using bridging technique and in 16 fractures (6 transverse and 10 wedge fractures) compression technique were used.

**Wound closure:** Deep fascia was never closed, subcutaneous tissue and Skin closure done in layers.

**Operative time:** In our study average operative time was 68 minutes and average tourniquet time of 54 minutes.

**Postoperative care:** Immediate postoperatively, the forearm was placed in a bulky, soft dressing including nearby joint (elbow or wrist). No patient was given external means of immobilization. Limb was kept elevated and finger movements were encouraged as early as possible. After 48 hours, the dressing was changed and a small occlusive dressing was given. Active elbow, wrist, finger, and shoulder

movements were encouraged and check x-ray was done. Skin suture or staples were removed on 12<sup>th</sup> postoperative day.

Patients were warned against forced passive motion, heavy lifting, and any activity that allowed blunt contact with forearm. The patients continued to be advised against full use of extremity until osseous union was confirmed on radiographic examination.

**Antibiotics:** Three doses of parenteral (preoperatively, intraoperatively and postoperatively) third generation cephalosporin were used. Then oral antibiotics were started from 2<sup>nd</sup> post operative day to 12<sup>th</sup> postoperative day (suture removal).

### Follow up

All the patients were interviewed in person at monthly follow up and detailed clinical and functional assessment were performed. Standardized anteroposterior view of both forearms with equal rotation of both forearm and lateral view of the injured forearm were done under supervision, including both elbow and wrist joints. The average duration of follow up was 12 months (Range 3-21 months).

Physical examination was performed on all patients at the follow up. Grip strength was measured by an indigenous method (using sphygmomanometer). Wrist elbow and forearm movements were measured using Goniometer. Normal range of movements was determined from the contra lateral, normal forearm.

### Quantification of normal radial bow (Emil H Schemitsch, Robin R Richards)<sup>[7]</sup>:

When the location of the maximum radial bow is within 4 to 5% of that of normal forearm, 80% of normal rotation of forearm and grip strength can be expected<sup>[7]</sup>.

**Functional outcome:** Assessed with the grading system of Anderson<sup>[1]</sup> which is based on the union of fracture, motion of forearm and elbow joints.

**Table 8:** Criteria of Anderson<sup>1</sup> to grade functional outcome

Results	Union	Flexion & Extension at elbow joint	Pronation & Supination at forearm
Excellent	Present	< 10° loss	< 25% loss
Satisfactory	Present	< 20° loss	< 50% loss
Unsatisfactory	Present	>20° loss	> 50% loss
Failure	Nonunion or unresolved chronic osteomyelitis		

**Union:** Union was assessed radiologically. Extension of trabeculae across the fracture, the presence of bridging callus and obliteration of fracture line were used as indicators of union.

Using the criteria of Anderson *et al*<sup>1</sup>, fractures that had healed by 6 months were considered as united: those that healed after 6 months without an additional operation procedure, as delayed union and those that failed to unite after 6 months or that needed an additional operative procedure to unite, as nonunion.

### Results

**Union:** Union occurred in all fractures at an average of 9 weeks (range 8-12wks). Radial fractures united at an average of 8.7 weeks and ulnar fractures united at an average of 9.3 weeks.

Among the 22 fractures fixed using the bridging technique, 20 fractures showed evidence of union with minimal external

bridging callus. Early evidence of callus was seen 3-6 weeks post surgery.

### Range of motion

In all 22 patients, the elbow range of motion was from 0° to full flexion.

Among 22 patients, 19 patients had forearm rotation (pronation/ supination) equal to that of the normal forearm; in 2 patients the forearm rotation was 90% of that of the normal forearm and in one patient the forearm rotation was 80% of the normal forearm.

Among 22 patients, 21 patients had grip strength equal to that of the normal forearm and in 1 patient the grip strength was 80% of the normal forearm.

Average maximal radial bow was 14.13 mm in the normal forearm. The difference in the amount of radial bow was not found to be affecting the forearm movements.

Average location of the maximal radial bow was 57.08% in

the normal forearm. As long as the location of the maximum radial bow was within 5% of the normal forearm, 80% of the forearm motion and grip strength was present.

When the location of the radial bow deviate more than 5% of that of the normal side, there was significant reduction in the range of motion of forearm and grip strength.

This relationship of forearm movements with the location of maximum radial bow was found more important in the fractures involving middle third fractures of the radius.

Time taken for full functional rehabilitation was an average of 2.5 months (2- 3 months).

**Functional outcome:** Based on anderson<sup>1</sup> criteria, All 22 patients had excellent outcome.

**Complications:** Two patients had superficial wound infection which was treated successfully with appropriate antibiotics based on culture studies.

One patient had superficial radial nerve injury with anterior approach for fracture lower third. No painful neuroma was formed. No further intervention was needed.

One patient had preoperative posterior interosseous nerve palsy (with fracture radius in the proximal third) which recovered by 6 weeks without surgical intervention.

One patient developed posterior interosseous nerve palsy with anterior approach for the fracture radius proximal third. Full recovery was attained by the end of 6 weeks of the surgery without surgical intervention.

Three Patients (two females, one male) developed hypertrophic scars (one female and male patient only in the radial incision; the other female in both incisions) for which no further intervention was done.

None of the cases had tourniquet palsy or cross union or compartment syndromes was seen.

**Table 9:** Complications

Complications	No of Patient	Percentage
Superficial infection	2	9
Superficial radial nerve injury	1	4.5
Posterior interosseous nerve injury	2 (1 preop, 1postop)	9
Hypertrophic scar	3	13.5
Total	8	36

**Removal of plate:** No patient underwent plate removal till the recent follow-up.

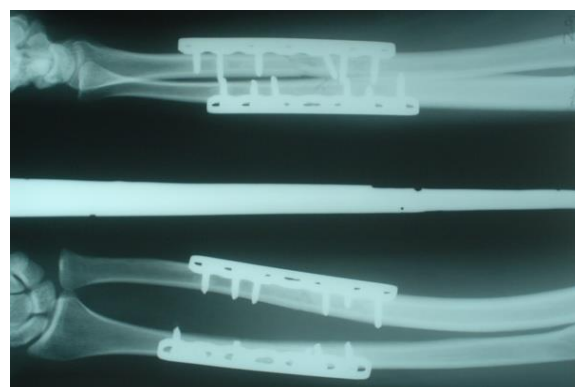
### Clinical Case Preop



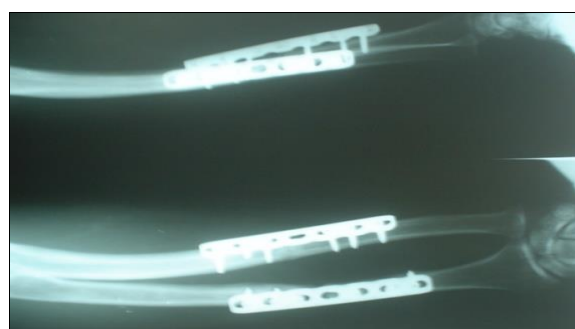
Postop



1 Month Postop



6 Months Postop



Elbow Flexion



Elbow Extension





Supination of Forearm



Dorsiflexion of Wrist



Pronation of Forearm



Palmarflexion of Wrist

### Discussion

Diaphyseal fracture of ulna and radius present specific problems in addition to those common to all fractures of shaft of long bones due to their anatomical characteristics and conservative treatment of these fractures lead to poor functional outcome.

Stoffel *et al.* <sup>[2]</sup> showed that plate osteosynthesis with rigid fixation has shown a high complication rate including delayed or nonunion, infection, hardware failure and most importantly refracture after plate removal, primarily due to necrosis of bone under the plate.

To evaluate surgical outcome of Locking Compression Plate osteosynthesis in fractures of forearm bones in adults and the outcome was analyzed and compared with the previously conducted studies as follows.

**Age distribution:** In our study, diaphyseal fractures of forearm bones were common in 3rd & 4th decade, with an average age of 32.77 years (16-60 years) which was comparable to previously conducted studies.

**Table 10:** Comparison of age groups between previous studies and our study

Series	Minimum age (yr)	Maximum age (yr)	Average age (yr)
H.N Burnwell <sup>[8]</sup>	16	57	44.8
Herbert dodge <sup>[9]</sup>	13	59	24
Chapman <sup>[10]</sup>	13	79	33
Moed B R <sup>[11]</sup>	14	65	22
F. Leung <sup>[12]</sup>	11	90	36
Sharma <sup>[13]</sup>	15	60	34
Saikia <sup>[14]</sup>	16	60	30.5
Ibrahim azboy <sup>[15]</sup>	16	74	28
Meena <sup>[16]</sup>	18	64	31.15
SPS Gill <sup>[17]</sup>	18	60	32.4
Rijal <sup>[18]</sup>	19	70	36.77
Our study	16	60	32.77

**Sex distribution:** our study had male preponderance with 81.8 % (18) males & 18.2 % (4) females which were comparable to previous studies. Male preponderance could be due to involvement of males in outdoor activities, industrial labour and sports activities as compared to their female counterparts.

**Table 11:** Comparison of sex distribution in previous studies and our study

Series	Male (%)	Female (%)
Herbert dodge <sup>[9]</sup>	89	11
Chapman <sup>[10]</sup>	78	22
F. Leung <sup>[12]</sup>	82.6	17.4
Sharma <sup>[13]</sup>	86.6	13.4
Saikia <sup>[14]</sup>	70	30
Ibrahim azboy <sup>[15]</sup>	77.3	22.7
SPS Gill <sup>[17]</sup>	73.07	26.93
Rijal <sup>[18]</sup>	60	40
Our study	81.8	18.2

**Mode of injury:** In our study, RTA contributes 54.5% and fall contributes to 45.5%

**Table 12:** Comparison of mode of injury in previous studies and our study

Series	Accident (%)	Fall (%)	Miscellaneous (%)
Sharma <sup>[13]</sup>	63.6	36.4	-
Meena <sup>[16]</sup>	50	30	20
Rijal <sup>[18]</sup>	33.3	50	16.7
Our study	54.5	45.5	-

Most of studies, mode of injury predominantly road traffic accident (RTA)

**Affection of forearm:** In our study, right (dominant) forearm affected in 22.72 % (5), left forearm affected in 72.28 % (17) and likely due to direct impact.

**Table 13:** Comparison affection of forearm in previous studies and our study

Series	Right (dominant)	Left (non-dominant)
H N Burnwell <sup>[8]</sup>	50%	50%
Chapman <sup>[10]</sup>	55%	45%
Meena <sup>[16]</sup>	61%	39%
SPS Gill <sup>[17]</sup>	53.8%	46.2%
Claudio Iacobellis <sup>[19]</sup>	38.3%	61.7%
Rijal <sup>[18]</sup>	43.3%	56.7%
Our study	22.72%	72.28%

**Location of fracture:** In our study, middle third region involved in 68.5 % (26), lower third region in 18.5 % (7) and upper third region in 13 % (5).

**Table 14:** Comparison of location of fractures in previous studies and our study

Series	Proximal third	Middle third	Distal third
Dodge <sup>[9]</sup>	71.5%	21.5%	7%
Chapman <sup>[10]</sup>	21%(R);13%(U)	59%(R);40%(U)	28%(R);12%(U)
Meena <sup>[16]</sup>	15%	55%	30%
Rijal <sup>[18]</sup>	10.3%	86.6%	3%
Our study	13%	68.5%	18.5%

**Type of fracture:** In our study, transverse fracture 15.8 % (6), wedge fractures 44.7% (17) and comminuted fractures 39.5 % (15).

**Table 15:** Comparison of type of fractures in previous studies and our study

Series	Transverse	Wedge	Comminuted
Chapman <sup>[10]</sup>	53%	-	47%
Leung <sup>[12]</sup>	37.5%	46.8%	15.6%
Sharma <sup>[13]</sup>	76.7%	23.3%	-
SPS Gill <sup>[17]</sup>	61.5%	34.6%	3.8%
Our study	15.8%	44.7%	39.5%

In our study, large number of wedge & comminuted fractures due to high energy injuries.

**Operative time:** In our study, we had average operative time of 68 minutes with average tourniquet time of 54 minutes.

**Table 16:** Comparison of operative time in previous studies and our study

Series	Operative time(min)
Ibrahim Azboy <sup>[15]</sup>	76
Meena <sup>[16]</sup>	70.25
Saikia <sup>[14]</sup>	93.5
SPS Gill <sup>[17]</sup>	80.8+/- 15.7
Our study	68

**Union time:** we used anderson<sup>1</sup> criteria; we had average union time of 9 weeks (8-12weeks), 100% union rate and comparable with previous studies.

**Table 17:** Comparison of union time in previous studies and our study

Series	Time of union (weeks)	Union (%)
Anderson <sup>[1]</sup>	7.4	97
Chapman <sup>[10]</sup>	12	98
Leung <sup>[12]</sup>	17	100
Saikia <sup>[14]</sup>	14.16	100
Meena <sup>[16]</sup>	12.8	100
Sharma <sup>[13]</sup>	12.6	93.3
Rijal <sup>[18]</sup>	16.83	100
Our study	9	100

**Functional outcome:** In our study, excellent results were found in all cases (100%).

**Table 18:** Comparison of functional outcomes in previous studies and our study

Series	Excellent (%)	Satisfactory (%)	Unsatisfactory (%)	Failure (%)
Anderson <sup>[1]</sup>	50.9	34.9	11.3	2.9
Chapman <sup>[10]</sup>	86	7	2	5
Leung <sup>[12]</sup>	98	2	-	-
Saikia <sup>[14]</sup>	89	8	3	-
Rijal <sup>[18]</sup>	83.3	16.6	-	-
Our study	100	-	-	-

With proper execution of technique of plating and proper post operative management in the 38 fractures of forearm bones in 22 adults, 100 % union rate was achieved in an average of 9 weeks with 100% excellent results. When compared with

other studies of forearm fractures fixed, our study showed better results based on anderson<sup>1</sup> criteria.

### Complications

**Table 19:** Comparison of complications in previous studies and our study

Complication	Anderson <sup>[1]</sup>	Chapman <sup>[10]</sup>	Leung <sup>[12]</sup>	Sharma <sup>[13]</sup>	Rijal <sup>[18]</sup>	Our study
Infection	2.9%	2.5%	3.1%	13.3%	6.7%	9%
Nonunion	2.9%	2.3%	-	-	-	-
Neuropraxia	2%	1.5%	-	-	-	13.5%
Radioulnar synostosis	1.2%	2.3%	-	-	-	-
Delayed union	-	-	6.25%	2%	-	-
Hypertrophic scar	-	-	-	-	-	13.5%

We had one superficial radial nerve injury without neuroma for lower radius fracture by Henrys approach that did not require any intervention, two posterior interosseous nerve palsy (preop-1, postop-1) which recovered by 6 weeks without surgical intervention, hypertrophic scar seen 3 patients likely due to familial background, did not required surgical intervention and two patients had superficial infection that was successfully treated with appropriate antibiotics based on culture studies and our complications were comparable to previous studies.

### Conclusion

Anatomic and stable fixation is essential to achieve maximum function in fractures of forearm bones. The Radial bow (amount and location) can be maintained by proper contouring of plate.

Stable internal fixation with locking compression plate and screws has shown to give low incidence of complications. Locking compression plate with a combi-hole provides fixation of fractures in a single implant with vast application according to the situation and very useful in wedge or osteoporotic or comminuted or complex fractures because it preserves periosteal blood supply and provides a stable fixation and ensuring early mobilisation.

Studies having a larger number of fractures treated with different modes are needed to evaluate the outcome of locking compression plate osteosynthesis in forearm bones fractures. but the early results are promising.

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