

## EVALUATION OF RESULTS IN FRACTURES OF BOTH BONES FOREARM TREATED WITH DYNAMIC COMPRESSION PLATING

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### ABSTRACT

#### BACKGROUND

The anatomical alignment of the bones, the length, the radial bow, and axis should be restored for a good functional outcome. Conservative treatment has resulted in malunion, non-union, synostosis and ultimately poor functional outcome. Internal fixation helps in perfect reduction of fracture fragments in anatomical position by rigid fixation and early mobilisation, the normal functions of the hand can be re-achieved at the earliest. This study has been taken up to evaluate the results of open reduction and internal fixation of the fractures of BBFA with DCP in adults and its advantages and complications. In this study, the rate and time taken for union, the complication, the functional results in terms of forearm rotation and wrist and elbow movements are evaluated.

#### MATERIALS AND METHODS

This study includes treatment of 20 cases of fracture of both bones of forearm by open reduction and internal fixation with 3.5 mm DCP from August 2013 to August 2015 at Department of Orthopaedics at Konaseema Institute of Medical Sciences, Amalapuram. Follow-up was done up to September 2015. This is a prospective time bound study. Sample size - 20 patients.

Inclusion Criteria- 1. Simple fractures. 2. Open fractures-Gustilo and Anderson type I and type II. 3. Age criteria = 15 to 70 years, both males and females.

Exclusion Criteria- 1. Age criteria 0 to 14 years & > 70 years. 2. Radiologically proven segmental fractures and isolated forearm bone fractures. 3. Pathological fracture. 4. Gustilo and Anderson type III. 5. Patient not willing for surgery. 6. Patient unfit for surgery.

#### RESULTS

The present study consists of 20 cases of fracture both bones of the forearm. All the cases were openly reduced and internally fixed with 3.5 mm DCP. The study period was from August 2013 to September 2015. The age of these patients ranged from 15-70 years with fracture being most common in 3<sup>rd</sup> decade and an average age of 31 years.

#### CONCLUSION

Use of separate incisions for radius and ulna and preservation of the natural curves of radius will lessen the rate of complications. Rigid fixation of fractures after perfect anatomical reduction with 3.5 mm DCP and screws allows early mobilisation, prevents soft tissue contracture, muscular tethering and improves vascularity. A minimum of 6 cortices have to be fixed in each fracture fragment and the nearest screw to the fracture line should be at least 1 cm away. It minimises vascular damage to the plated bone segment.

#### KEYWORDS

Forearm Fracture, Dynamic Compression Plating.

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#### BACKGROUND

The supporting skeleton and articulations of the upper extremity serve to position its terminal unit, the hand, in

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space. In the adult, exact management of diaphyseal fractures of the radius and ulna is necessary to ensure forearm movements. Unsatisfactory treatment can lead to loss of motion as well as muscle imbalance and disability of hand function.

The incidence of forearm fractures are increasing faster than the predicted rate due to increase in population, increasing number of vehicles, rapid industrialisation. Increased incidence of violence and various sports activities have contributed to the increased incidence of fractured shaft of both bones forearm.

The reasons for higher rate of non-union and malunion as well as poor functional outcome, are due to complex

anatomical structure with coordination between muscles, tendon, bones and joints which is responsible for the multifold functions of the arm and hand including pronation and supination where the radius rotates around the ulna.

The anatomical alignment of the bones, the length, the radial bow, and their axis should be restored for a good functional outcome. Conservative treatment has resulted in malunion, non-union, synostosis and ultimately poor functional outcome. Internal fixation helps in perfect reduction of fracture fragments in anatomical position by rigid fixation and early mobilization, the normal functions of the hand can be re achieved at the earliest. This study has been taken up to evaluate the results of open reduction and internal fixation of the fractures of BBFA with DCP in adults and its advantages and complications. In this study the rate and time taken for union, the complication, the functional results in terms of forearm rotation and wrist and elbow movements are evaluated.

### **MATERIALS AND METHODS**

This study includes treatment of 20 cases of fracture of both bones of forearm by open reduction and internal fixation with 3.5 mm DCP from August 2013 to August 2015 at Department of Orthopaedics at Konaseema Institute of Medical Sciences, Amalapuram. Follow-up was done up to September 2015.

This is a prospective time bound study. Sample size - 20 patients.

#### **Inclusion Criteria**

- Simple fractures.
- Open fractures-Gustilo and Anderson type I and type II.
- Age criteria = 15 to 70 years, both males and females.

#### **Exclusion Criteria**

- Age criteria 0 to 14 years & > 70 years.
- Radiologically proven segmental fractures and isolated forearm bone fractures.
- Pathological fracture.
- Gustilo and Anderson type III.
- Patient not willing for surgery.
- Patient unfit for surgery.

#### **Evaluation**

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 immobilised in above elbow Plaster of Paris slab with sling.

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

Radius was approached by Volar Henry approach and ulna as it is a subcutaneous bone, incision given directly over it. A narrow 3.5 mm DCP was used and a minimum of 6 cortices were engaged with screw fixation in each fragment.

#### **Preoperative Planning**

- After studying the x-ray, fracture was classified and pattern was assessed. The patient was counselled for surgery.
- Consent of the patient or relative was taken prior to the surgery.
- After deciding the length of the plates, all instruments required, plate and screws were sterilised.
- Soap water enema on the previous night and on the morning of the day of surgery was given.
- Preparation of the part was done the night before surgery.
- A dose of tetanus toxoid and prophylactic antibiotic (3rd generation cephalosporins) were given preoperatively before one hour of surgery.

#### **Position**

- Patient is supine on the operating table.
- Pneumatic tourniquet is used for minimising the blood loss during surgery.
- For Henry's approach - the arm is placed on an arm board with elbow straight and forearm in supination position.
- For Thompson approach - the arm on the arm board, elbow flexion and forearm in mid pronation position.

#### **Type of Anaesthesia**

General anaesthesia was used in 12 cases and brachial block in 8 cases.

#### **Operative Procedure**

After anaesthesia, part was painted and draped. The radius was approached by Volar Henry's approach. Henry's approach allows a wide exposure of the anterior surface of the radius and exposes the bone over its entire length, if required. The approach can be extended across the elbow and into the hand. 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, middle, distal thirds, the plate was fixed on the volar aspect. In ulna fractures plate was applied over the posteromedial surface of ulna.

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 under surface 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.

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 comminuted fractures long plate was used to achieve adequate stability and prevent mechanical overload and failure.

Once stable fixation is achieved and haemostasis secured meticulously, the wound is closed 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. Postoperatively wound was inspected after 2 to 3 days. IV Antibiotics (3<sup>rd</sup> generation cephalosporin's) for first 5 days and converted to orals for next 5 days and analgesics (diclofenac) were given to the patient till the time of suture removal. Sutures were removed on 10<sup>th</sup> postoperative day. In grossly comminuted patients posterior slab was given for 3 weeks unless it is a stable rigid fixation.

**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 movements is expected. These isotonic exercises are very much essential for the excellent outcome. Physiotherapy helps in fracture union by increasing blood supply and preventing muscles from getting tethered to bone and soft tissues from contractures.

**Follow-up**

All the patients were followed up at 6 weeks, 3 months and 6 months and evaluation was done based on "Anderson et al scoring system".

Elbow movements and wrist movements were noted and the union was assessed radio logically. The fracture is

designate as united when there were no subjective complaints, radiologically when the fracture line was not visible.

The patient rated outcome was assessed using the disabilities of the arm, shoulder and hand (Quick DASH) questionnaire, an 11 item similar questionnaire in regional language has been asked to assess the functional symptoms of patients.

The DASH scoring was performed from 6 months onward. The score at the latest follow-up was considered.

**RESULTS**

The present study consists of 20 cases of fracture both bones of the forearm. All the cases were openly reduced and internally fixed with 3.5 mm DCP. The study period was from August 2013 to September 2015.

Age	No. of Patients	Percentage
15 - 20	2	10
21 - 30	6	30
31 - 40	8	40
41 - 50	2	10
51 - 60	2	10
61 - 70	0	0
<b>Total</b>	<b>20</b>	<b>100</b>

*Table 1. Age Distribution*

The age of these patients ranged from 15-70 years with fracture being most common in 3<sup>rd</sup> decade and an average age of 31 years.

Sex	No. of Patients	Percentage
Male	14	70
Female	6	30
<b>Total</b>	<b>20</b>	<b>100</b>

*Table 2. Sex Distribution*

Out of 20 patients, 14 patients (70%) were male and 6 patients (30%) were female, showing male preponderance because of working in fields and motor vehicle accidents.

Side affected	No. of Patients	Percentage
Right	6	30
Left	14	70
<b>Total</b>	<b>20</b>	<b>100</b>

*Table 3. Side Affected*

In the present study out of 20 patients, 6(30%) were with right forearm fracture and 14 (70%) patients were with left forearm fracture.

Mode of Injury	No. of Patients	Percentage
RTA/WORK PLACE	13	65
Fall	7	35
Assault	0	0
<b>Total</b>	<b>20</b>	<b>100</b>

*Table 4. Mode of Injury*

In the present study of mode of injury, 13 (65%) patients were due to road traffic accidents, 7 (35%) patients were due to fall (accidental falls on road, at work place, at home).

**Fracture Characteristics**

Level of Injury	No. of Patients	Percentage
Middle third fractures	9	45
Proximal third fractures	5	25
Lower third fractures	6	30
<b>Total</b>	<b>20</b>	<b>100</b>

*Table 5. Level of Fracture*

Majority of the fractures were seen in the mid diaphysis of both bones. 9 (45%) patients had middle third fractures, 6 (30%) had lower third fractures and 5 (25%) patients had proximal third fractures both bones forearm.

Type of Fracture	Radius	Ulna
Transverse/short oblique	18	19
Comminuted	2	1
<b>Total</b>	<b>20</b>	<b>20</b>

*Table 6. Type of the Fracture*

Majority of the fractures were transverse/short oblique. About 10% of radius and 5% of ulna fractures were comminuted.

Associated Injury	No. of Cases	Percentage
Fractured shaft humerus (Lt)	1	5
<b>Total</b>	<b>1</b>	<b>5</b>

*Table 7. Associated Injuries*

Only 1 (5%) patient had associated injuries.

**Statistics of Surgery**

12 of the 20 cases were operated under general anaesthesia and in other 8 patients brachial block was used.

Volar Henry’s approach was used for all 20 cases.

Ulna was approached subcutaneously. Pneumatic tourniquet was used in all cases.

Follow-up ranged from 4 weeks to 18 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 80 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, radio logically 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.

Time of union	No. of Cases	Percentage
< 4 months (16 weeks)	15	75
4 - 6 months (16 – 24 weeks)	5	25
6 months - 1 year (24 - 36 weeks)	0	0
<b>Total</b>	<b>20</b>	<b>100</b>

*Table 8. Duration of Fracture Union*

20 (100%) patients had good union in less than 6 months.

**Complications**

**Intraoperative Complications**

There were no cases of intraoperative complications.

**Postoperative Complications**

1. Superficial Infections: One patient developed superficial infection. Infection was controlled with appropriate antibiotics after culture and sensitivity report.
2. No other complications like posterior interosseous nerve injury or radioulnar synostosis were observed.

Complications	No. of Cases	Percentage
Superficial infection	1	5
<b>Total</b>	<b>1</b>	<b>5%</b>

*Table 9. Complications*

Results	No. of Cases	Percentage
Excellent	19	95
Satisfactory	1	5
Unsatisfactory	0	-
<b>Total</b>	<b>20</b>	<b>100</b>

*Table 10. Functional Results*

A high DASH score indicates greater disability that a true change in function and symptoms has occurred. A 10-point difference in scores may be considered the minimal change for clients who have undergone surgery.

Using the Anderson et al scoring system and quick DASH scoring, we had 19 (95%) patients with excellent results, 1 (5%) patient with satisfactory results.

**DISCUSSION**

Fracture both bones of forearm are commonly encountered in day-to-day orthopaedic practice in our hospital and it presents a formidable challenge to the orthopaedicians, as the various muscle forces acting upon the fracture tend to displace it. Hence to provide the functional rehabilitation of the upper limb, anatomic reduction and rigid fixation is mandatory.

As reported by Knight and Purvis closed reduction and its maintenance is difficult. Implants like intramedullary nails have got high failure rate though there are few advantages with closed nailing like minimal tissue dissection and less

hospital stay, the dynamic compression plates (DCP) are best implants for diaphyseal fractures of forearm for rigid fixation and early mobilization.

The present study was undertaken to determine the efficacy of DCP in the treatment of diaphyseal fracture of both bones of the forearm. A total of 20 patients of fracture both bones of forearm were treated with open reduction and internal fixation using 3.5 mm DCP.

Results were compared with those obtained by various other studies utilizing different modalities of treatment.

**Our Analysis is as follows-  
Age Distribution**

In the present study, fracture was common in third and fourth decade with average age of 32 years.

The findings are comparable to the study made by Moed BR<sup>1</sup> and Chapman et al<sup>1</sup> in 1986 witnessed 70% of patients between third and fourth decade and an average of 33 years.<sup>1</sup>

Series	Minimum Age (Years)	Maximum Age (Years)	Average Age (Years)
Herbert Dodge	13	59	24
Michael Chapman	13	79	33
Moed BR	14	65	22
Schemitsch et al	16	83	24
Frankie Leung	11	90	36
Present study	15	60	32.5

**Table 11. Age Distribution**

**Sex distribution**

In the present study, there was male preponderance with 70% males and 30% female patients, this was comparable to 1964 Burwell et al and William AT studies. In most of the series males are affected more.<sup>2</sup>

Series	Males (%)	Females (%)
Herbert Dodge	89	11
Michael Chapman	78	22
William AT	67	33
Frankie Leung	82.6	17.4
Burwell et al	69.33	30.67
Present study	70	30

**Table 12. Sex Distribution**

**Mode of Injury**

In the present study, RTAs were 13 (65%), accidental falls 7 (35%) (On road, at work place, at home) and there are no assault cases.

Moed BR et al accounted 50% of his cases to RTA, 20% due to industrial accidents, 14% due to fall, 12% due to direct blow and 4% due to gunshot injuries.<sup>3</sup> Thomas Grace et al noted about 29 (45%) patients with automobile/motorcycle accidents, 14 (22%) falls, 2 (3%) had gunshot wounds and remainder had other miscellaneous types of injuries.<sup>4</sup> Smith noted about 45% of

his cases were due to RTA, 36% were due to falls and 19% were due to industrial accidents.

Series	RTA (%)	Fall (%)	Direct Blow/Miscellaneous (%)
Moed	70	14	16
Grace	45	22	33
Schemitsch et al	34.55	38.18	27.73
Present study	65	35	-

**Table 13. Mode of Injury**

**Extremity Affected**

In the present study, incidence of fracture of both bones in left extremity accounted about 70%, which is not comparable to previous studies which show increased trauma incidence. Burwell HN and Charnley AD reported about 50% incidence of fracture both bones in left forearm.<sup>3</sup> 1992 Schemitsch et al reported about 55% incidence of fractures of both bones in left extremity.<sup>5,6</sup>

But it is always difficult to determine the exact sequence of events in RTA or fall.

Series	Right (%)	Left (%)
Burwell HN	49.33	50.67
Michael Chapman	55	45
Schemitsch et al	43.63	56.37
Present study	30	70

**Table 14. Side Affected**

**Fracture**

**Anatomy**

**Type of Fracture**

In the present study, 85% of fractures were transverse/short oblique, and 15% were comminuted out of which 10% are seen in radius and 5% in ulna. The results were not comparable to the previous studies, which can be attributed to low velocity trauma in our country.

Series	Transverse/Short Oblique (%)	Comminuted (%)
Present study	85	15

**Table 15. Type of Fracture**

**Level of Fracture**

In the present study, there were 45% of fractures in middle third, 25% proximal and 30% in lower third. In all reported series, the incidence of fracture is highest in the middle third and least in the proximal third. Sarmiento A et al noted about 84.6% of fractures on both bones were in middle third and 15.4% of cases had lower third fracture of both bones.<sup>7</sup>

Chapman MW et al noted about 59% and 40% of fractures in middle third of radius and ulna, 13% and 21% in proximal third of radius and ulna and 28% and 12% in lower third of radius and ulna respectively<sup>1</sup> which is compared to our series.

Series	Proximal Third (%)	Middle Third (%)	Distal Third (%)
Herbert Dodge	7.14	71.42	21.44
Sarmiento	-	84.6	15.4
Chapman	13	59	28
Present study	25	45	30

**Table 16. Level of Fracture**

**Complications**

In the present study, there was one case of superficial infection. Pus was sent for culture and sensitivity and appropriate antibiotics as per sensitivity report (Cefoperazone/Sulbactam) were administered and wound healed well in further follow-ups.

Complications	Anderson <sup>8</sup>	Chapman <sup>1</sup>	Present Study
Superficial infection	2.9%	2.5%	5%
Non-union	2.9%	2.3%	-
Post-interosseous nerve injury	2%	1.5%	-

**Table 17. Complications**

**Functional Results**

In the present study, results were 19 (95%) with excellent results, 1 (5%) as satisfactory. Anderson scoring system and dash scoring system were used to measure functional outcome. Fracture union and range of movements are the two factors, which affect the functional outcome.

Series	Excellent (%)	Satisfactory (%)	Unsatisfactory (%)	Failure (%)
Anderson	50.9	34.9	11.3	2.9
Chapman	86	7	12	5
Frankie	98	2	-	-
Burwell	77	23.8	10.8	1.4
Present study	95	5	-	-

**Table 18. Functional Results**

**Duration of follow-up**

In the present study, patients were followed up regularly from 4 weeks to 18 months, with an average mean of 12 months, which can be compared to Chapman series but other series had longer follow-up.

Series	Range	Average
Anderson	4 months - 9 years	3 years
Chapman	6 months - 48 months	12 months
Moed	12 months - 9 years	3 years
Present study	3 months - 18 months	12 months

**Table 19. Duration of Follow-up<sup>8,9</sup>**

**CONCLUSION**

DCP facilitates biological fixation of the bone and early bone union. It is easier to apply in comminuted and short oblique fractures.

Use of separate incisions for radius and ulna and preservation of the natural curves of radius will lessen the rate of complications.

Rigid fixation of fractures after perfect anatomical reduction with 3.5 mm DCP and screws allows early mobilisation, prevents soft tissue contracture, muscular tethering and improves vascularity.

A minimum of 6 cortices have to be fixed in each fracture fragment and the nearest screw to the fracture line should be at least 1 cm away.

It minimises vascular damage to the plated bone segment.

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.

Complications after a well-performed surgery are minor and easily correctable.

Postoperative mobilisation and return to the normal as early as is possible. This study concludes that DCP is one of the best procedures for diaphyseal fracture of both bones forearm and should be used as the implant of choice.

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