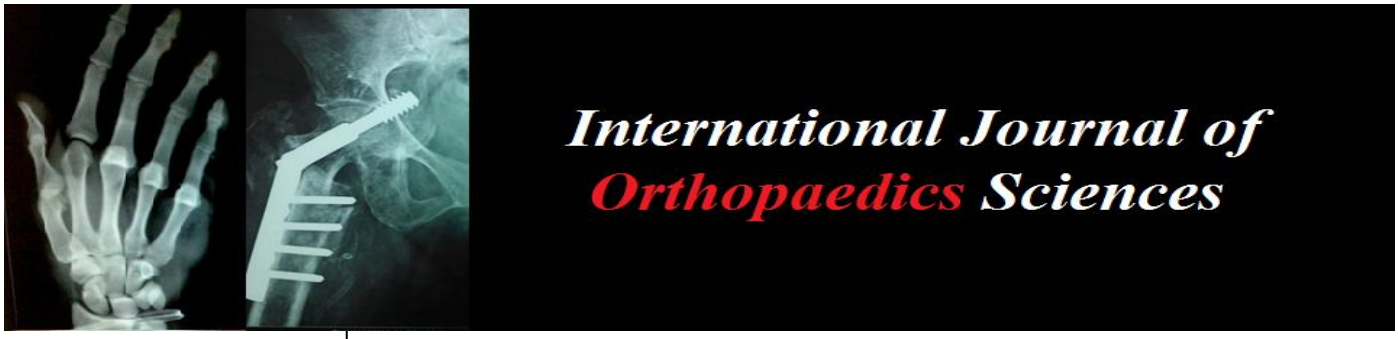

ISSN: 2395-1958
IJOS 2019; 5(3): 659-665

www.orthopaper.com
Received: 17-04-2019
Accepted: 23-05-2019

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Management of fracture both bone of forearm with dynamic compression plating and its outcomes

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DOI: https://doi.org/10.22271/ortho.2019.v5.i3l.1609

Abstract
Introduction: Forearm fractures are one of the most common injuries encountered by an orthopaedic surgeon. Before AO (Association for Osteosynthesis), they were treated with cast immobilization and also other fixation techniques which were described such as intramedullary k-wire, intramedullary nail, external fixator etc. Though still relevant today, however they have been demonstrated to be successful only in selected cases, with high rate of non-union, malunion and with ill effects on the functions of the forearm. The most effective method of producing rigid internal fixation by the use of compression plates was developed by AO School in Switzerland.
Objective: The aim of this study is to assess the results of fixation of fractures of shaft of both bone of forearm with dynamic compression plating (DCP) and its advantages and its complications
Setting: This study was conducted at the orthopedics department of a teaching hospital in India.
Design: This was 2 years prospective, longitudinal, hospital based, observational study, and its outcomes.
Participants: The study was done in 30 patients (22 males and 8 females) with fracture both bone of the forearm, who were treated with open reduction and internal fixation with dynamic compression plate and screws at Mahatma Gandhi Memorial Hospital (attached to Kakatiya Medical College, Warangal), between January 2017 to January 2019.
Results: Anderson's criterion was employed to categorize the functional results. Good or full range of mobility of elbow and wrist joints, with excellent and satisfactory results was present in 28 patients (94%), 1 patient (3%) having restriction of elbow motion and pronation and supination and 1 patient (3%) with non-union of ulna, who recovered with bone grafting.
Conclusion: Based on our experience and results, we conclude that with anatomic open reduction and rigid internal fixation with dynamic compression plate is a good fixation procedure for displaced diaphyseal fractures of both bone of the forearm. Adherence to strict asepsis, AO principles, proper post-operative rehabilitation and patient education are more important to obtain excellent results.

Keywords: Anderson scoring system, diaphysis, dynamic compression plate, fracture both bone of forearm, internal fixation, radial bow.

Introduction

The forearm, being a component of upper limb provides stable base for spatial positioning of hand and serves important movements in activities of daily living. The forearm with two parallel bones, radius and ulna, in combination with the proximal and distal radioulnar joints, allows forearm rotation (pronation and supination) which in turn helps the hand, to perform multi axial movements [1].

The incidence of forearm fractures is increasing at a faster rate than predicted, due to increase in the number of vehicles, rapid industrialization, increased incidence of assaults, and various sport activities. Fracture of the forearm bones may result in severe loss of function unless adequately treated. It is essential to achieve apposition, regain length, rotational alignment and restoration of the radial bow [2] while treating fractures of both radius and ulna, to gain good range of pronation and supination. In presence of pronating and supinating muscles which have angulatory and rotatory influence, the reduction and maintenance of displaced fracture fragment is difficult [3]. Healing occurs reliably after closed treatment, but malunion with resultant decreased rotation of forearm is common and associated with poor results. With the development of compression plate Osteosynthesis [4] which provides a good treatment option and predictable outcome, there is an important change in the treatment of forearm fractures.

The functional outcome was assessed using Anderson scoring system [5].

Methodology

The present study included 30 patients attending OPD and emergency department and diagnosed with displaced fractures of the shafts of both bone of forearm, who are treated by open reduction and internal fixation with 3.5 mm dynamic compression plate (DCP) and screws. This study was conducted from January 2017 to January 2019 in the Department of Orthopaedics, Mahatma Gandhi memorial Hospital (affiliated to Kakatiya Medical College, Warangal).

All patients were informed about the study, and their consent was obtained for their inclusion in this study. Ethical approval was taken from the Institutional Ethics Committee.

Inclusion Criteria

- Patients with closed diaphyseal fractures of both bone of forearm.
- Patients in the age group of 14-65 years
- Patients fit for surgery

Exclusion criteria

- Patient not willing for surgery
- Patient medically unfit for surgery
- Open fractures
- Pathological fractures
- Radiological presence of segmental fracture
- Single bone fracture of forearm

Data recording: (Clinical and Radiological)

In all patients admitted with fracture both bone of the forearm, a detailed history was elicited from the patient and/or their attendants to reveal the mechanism of injury and the severity of trauma.

The patients were then evaluated clinically regarding their general condition and the local injury. It was done in accordance to Acute Trauma Life Support protocol. Vital parameters were recorded. A thorough clinical examination was done to rule out fractures at other sites. Local examination of injured forearm and hand, such as attitude and position of the affected upper limb compared with normal counterpart, any swelling, open wounds, deformity and loss of function was noted.

Palpation was done to check for tenderness, any breach in continuity of bone, any abnormal mobility, crepitus and shortening of the forearm. Distal vascularity was assessed by radial artery pulsations, capillary refill time, and pallor at finger tips. In neurological examination, pain and touch sensation in the radial, ulnar and median nerve innervated areas were evaluated. Power including hand grip was tested in forearm and hand muscles. Movements at elbow, forearm and wrist were examined and any restriction of motion and pain was recorded.

Imaging: Radiographs of the affected forearm in both anteroposterior and lateral views, were obtained. The elbow and wrist joints were included in each view. (Figure 1)

Management protocol

In the meantime, analgesics were given and the limb was then immobilized in above elbow Plaster of Paris slab with sling. Routine blood investigations like CBP, RBS, Blood Urea, Serum Creatinine, Serum Electrolytes, Blood grouping and typing, HIV, HBSAg; and ECG, chest X-ray were done.

Preoperative planning

- Consent of the patient or relative was taken prior to the surgery.
- Preparation of the part was done the night before surgery
- A dose of tetanus toxoid and prophylactic antibiotic (3rd generation cephalosporin) were given preoperatively.
- With the help of radiographs, appropriate length of the plate (3.5mm narrow DCP), kind of application, need for lag screw and need for any bone graft was determined provisionally.

Technique of ORIF

Type of anaesthesia: General anaesthesia was used in 14 cases and brachial block in 16 cases.

Patient Positioning: Patient was placed supine on the operating table with limb supported on arm rest. In order to minimize blood loss during surgery, pneumatic tourniquet was used on the upper arm. Painting and draping of the part was done.

The bone which has a simple fracture (less comminuted) and more stable is fixed first and if equally comminuted, radius is fixed first.

Approaches: Two separate incisions for both radius and ulna, preserving a broad skin bridge between the two incisions were used to avoid the risk of radio ulnar synostosis and nerve injury [6]. The following are the approaches [7] which were used to surgically expose both bones of the forearm.

Radius

- **Volar Henry's** approach to radius was used for distal 3rd and middle 3rd fractures.
  - Landmarks include proximally, a groove between the distal biceps tendon and brachio radialis, and styloid process of the radius distally. For deep dissection, the inter-nervous plane lies between brachioradialis and pronator teres proximally and brachioradialis and flexor carpi radialis distally.
- **Postero-lateral Thompson's** approach was used for proximal 3rd and middle 3rd fractures.
  - Landmarks include a point 1.5 cm anterior to the lateral epicondyle of humerus proximally, and lister's tubercle of the radius distally. For the deep dissection, the internervous plane lies between the extensor carpi radialis brevis and extensor digitorum communis.

Ulna

- Skin incision runs parallel to the subcutaneous border of the ulna, and landmarks include the tip of olecranon and the styloid process of ulna. The inter-nervous plane between extensor carpi ulnaris and flexor carpi ulnaris.

After identifying the fracture ends, periosteum was stripped to a minimum and the fracture ends were cleaned. Fracture was reduced and interdigitation of the fracture fragments ensured perfect reduction. A dynamic compression plate of appropriate length is applied to the bone with middle portion of plate placed over the fracture, and is held with reduction forceps.

During fixation the importance of adequate compression of fracture and plate is ensured to overcome any torsional forces. A plate of at least 7 holes was chosen and longer plates were used in spiral, segmental and comminuted fractures. There should be 6 cortices secured by screws or 3 bicortical screws

in each main fragment. For upper third radial fractures the plate was fixed dorsally. For middle third, the plate was fixed dorsolateral and for distal third radial fractures the plate was fixed on the volar aspect. In ulnar fractures, plate was applied over the postero-lateral (extensor) surface of ulna.

The plate hole close to the fracture in one fragment is drilled using 2.5mm drill bit. After drilling a hole in both cortices, the length of 3.5mm screw is determined with depth gauge [8]. A tap of 3.5 mm [9] is used to cut the thread in the hole. In case of oblique fractures, the first screw is applied to the fragment, which forms an obtuse angle with the fracture near the plate. This is followed by drilling of a plate hole in eccentric mode close to the fracture in other large fragment.

If compression is sufficient, the remaining screws are applied one by one, alternating from one side to the other in neutral mode. In case of porotic, comminuted and/or small bones, long screws and/or a longer plate were used. Finally all screws were tightened.

After fixing of both bone fracture, the forearm rotations were checked intraoperatively. Tourniquet is deflated and ensuring haemostasis, the wound is closed (fascia is not closed) over a suction drain and sterile dressing is applied.

Post-operative treatment

Post operatively the limb was immobilized in above elbow slab and arm pouch was given depending upon the requirement.

Limb is elevated and active movements of the fingers are encouraged. Distal neurovascular status was checked periodically. Intra venous antibiotics (3rd generation cephalosporins) were started and post-operative analgesia was ensured. Suction drain was removed after 48 hours and surgical wound was inspected and aseptic sterile dressing was done. Check X ray of operated forearm with elbow and wrist joints in AP and Lateral view was taken at that time.

Intra venous antibiotics were given for the first 5 days followed by oral drugs till the 12th day. Analgesics were also continued till the time of suture removal, which was done on 10th-12th postoperative day.

On discharge patient was advised physiotherapy which includes early functional range of movement exercise for the shoulder, elbow, wrist and fingers. They were told not to lift heavy weights [10] or exert the affected forearm.

Follow up protocol

The patients were followed regularly at outpatient department initially on 3rd and 6th week, and thereafter monthly for 6 months and then at an interval of every three months depending upon the outcome, up to 2 years. Clinico-radiological follow up was done at each follow up.

The patients were evaluated based on Anderson *et al*. scoring system (Table 1). Elbow movements and wrist movements (Figure 2) were noted and the union was assessed radiologically (Figure 1). The fracture is said to be united when there was presence of periosteal callus bridging the fracture site or of trabeculation extending across the fracture line.

Table 1: Anderson's Criteria for Assessment of functional outcome

Results	Fracture Union	Flexion/Extension at wrist joint	Supination and pronation of forearm
Excellent	Present	$<10^0$ loss	<25% Loss
Satisfactory	Present	$<20^0$ loss	<50% Loss
Unsatisfactory	Present	$<30^0$ loss	>50% loss
Failure	Non-union with or without loss of motion		

Observations & Results

The present study consists of 30 patients with displaced fractures of the shaft of both bone of forearm which were treated by open reduction and internal fixation with 3.5 mm dynamic compression plate (DCP) and screws.

In our series using the Anderson *et al*. scoring system, we had 24(80%) patients with excellent results, 4(13.32%) patients with satisfactory results and 1(3.33%) patient with unsatisfactory result and 1(3.33%) patient had failure (Table 2). The failure was due to non-union of fracture of ulna which was later treated by open reduction and internal fixation with bone graft.

Table 2: Functional Results

Results	Number of Patients	Percentage
Excellent	24	80.00%
Satisfactory	4	13.32%
Unsatisfactory	1	3.33%
Failures	1	3.33%

In our series, we had complications in 13.33% (n=4), which were as follows (Table 3)

Table 3: Complications

Complications	No. of cases	Percentage
Superficial infection	2	6.66%
Deep infection	0	0
Radioulnar synostosis	0	0
Non-union	1	3.33%
malunion	0	0
Posterior interosseous nerve injury	1	3.33%
Bone shortening	0	0
Total cases with complications	4	13.33%

Fig 1: Clinico- radiological course in management of fracture of both bone of forearm with plate osteosynthesis.

Fig 2: Elbow and wrist movements of the patient during follow up.

Discussion

The forearm being a component of upper limb, its movements are important for activities of daily living. The forearm, allows pronation and supination, which in turn helps the hand to perform multi axial movements.

Fracture of the forearm bones may result in severe loss of function unless adequately treated. Hence a good anatomical reduction and internal fixation of these fractures is necessary to restore function.

This study was conducted at our hospital with the aim to know the importance of anatomical reduction and rigid fixation of forearm diaphyseal fractures with 3.5 mm DCP, as this in turn influenced the functional results obtained.

We evaluated our results and compared them with those obtained by various other studies. Our analysis is as follows.

1. Age distribution

The age of these patients ranged from 14-65 years and an average age of 38 years. Our findings are comparable to the study made by Michael W.Chapman *et al*. [11] series which showed average age as 33 years.

H.N. Burwell *et al*. [12] witnessed 50% of the patients between second and third decade and an average of 44.8 years.

Herbert S.Dodge *et al*. [13] found 24 years as the average age in their series. B.R. Moed *et al*. [14] found the average age was 22years.

Table 4: Age Distribution

Series	Min. Age (yrs)	Max. Age (yrs)	Average (yrs)
Michael Chapman	13	79	33
Herbert Dodge	13	59	24
H.N. Burwell	17	79	44.5
Present study	11	65	38

2. Sex distribution

Our series had male preponderance with 73.33 % (n=22) male patients and 26.66% (n=8) female patients which were comparable to previous studies. Michael Chapman noted about 78% males and 22% females. A.K. Talwalkar [15] in his series had 80% males and 20% females. William A.T. *et al*. [16] in his series had 67% of males and 33% of females. H. Dodge in his study noted about 89% males and 11% females.

Table 5: Sex Distribution

Series	Males (%)	Females (%)
M.Chapman	78	22
Talwalkar	80	20
William A.T.	67	33
H.Dodge	89	11
Present study	73.33	26.66

3. Mode of injury

In our series, 36.66% (n=11) of cases had road traffic accidents, 50% (n=15) had a fall, and 13.33% (n=4) with history of assault. Moed B.R. *et al*. accounted 50% of his cases to road traffic accident, 20% due to industrial accident, 14% due to fall, 12% due to direct blow and 4% due to gunshot injuries.

Thomas Grace *et al*. [17] noted about 45% (n=29) patients with automobile or motorcycle accident, 22% (n=14) in falls, 33% (n=2), had gunshot wounds and remainder had other miscellaneous types of injuries.

Smith [18] noted about 45% of his cases was due to RTA, 36% were due to fall and 19% were due to industrial accidents.

Talwalkar series had 26.6% of his cases due to road traffic accident, 16.6% due to industrial accident, 50% due to fall and 6.6% due to direct blow.

Our series is not comparable to the previous series.

Table 6: Mode of Injury Distribution

Series	Road traffic accident (%)	Fall (%)	Direct blow/assault (%)	Industrial accident/fall of heavy Object
Moed	50	14	16	20
Grace	45	22	-	33
Smith	45	36	-	19
Talwalkar	26.6	50	6.6	16.6
Present Study	36.66	50.00	13.33	-

4. Extremity affected

We had about 50% incidence of forearm fractures in right and 50% in left extremity, which is also comparable to the previous studies.

M. W. Chapman reported about 55% incidence of fractures in right extremity.

H.N. Burwel & AD Charnley reported about 49% incidence in the right forearm.

Table 7: Extremity Affected Distribution

Series	Right (%)	Left (%)
H.N.Burwell	49	51
M.W.Chapman	55	45
Present study	50.00	50.00

5. Fracture anatomy

a. Type of fracture

As we had included diaphyseal fractures of both bone, in our study, in total we had total of 30 radius shaft fractures and 30 ulna shaft fractures.

Among 30 radius, 7(23.33%) were Transverse, 15(50%) were short oblique type and 8(26.66%) were comminuted variety.

Among 30 ulna, 3(10%) were Transverse, 19(63.33%) were short oblique type and 8(26.66%) were comminuted variety.

M. W. Chapman *et al*. series noted about 53% of fractures as comminuted and 47% were transverse/short oblique.

On an average we had 65.33% with Transverse/short oblique type and 33.66% were comminuted variety.

Ours were not comparable to any of the studies available.

b. Level of fracture

M. W. Chapman *et al.* noted about 59%(n=37) and 61%(n=40) of fractures in middle third of Radius and ulna, 13%(n=8) and 21%(n=14) in proximal third of radius and ulna and 28%(n=18) and 12%(n=12) in lower third of radius and ulna respectively.

A. Sarmiento *et al*. [19], noted about 84.6% of fracture both bone were in middle third and 15.4% of cases had lower third fracture of both bone.

H.S. Dodge documented 71.42% fracture both bone in middle third, 21.44% in distal third and 7.14% in proximal third.

Our study had 56.33% of fractures in middle third, 26.66% in proximal third and 16.66% in lower third, comparable to the previous studies.

6. Time for union

Anderson's criteria for evaluation of union were taken into account.

Anderson showed average union time of 7.4 weeks, and with a range of 5 to 10 weeks, 97% of the cases united.

Chapman in a study had 97% union rate, with a range of 8 to 24 weeks, the average union time was 12 weeks.

Mc Kee [20] study had average union time of 10.7 weeks, with a range of 5 to18 weeks. He had 97.3% union rate.

The present series had average union time of 12 weeks, with a range of 8 to 24 weeks. Fracture of radius united in all cases and we had union of fracture of ulna in 96.6% of cases.

The results of our present studies are comparable to the previous studies.

7. Functional results

The range of motion was determined and Anderson *et al*. scoring system was used as a measure for the functional outcome.

Chapman *et al*. reported 91% (n=79) cases as excellent and satisfactory, 7% (n=6) unsatisfactory and 2% (n=2) failure.

Anderson *et al*. reported about 50.9% (n=54) cases as excellent, 34.9% (n=37) satisfactory, 11.3% (n=12) unsatisfactory and 2.9% (n=2) failure.

In our series we had 80% (n=24) cases with excellent results, 13.32% (n=4) were satisfactory and 3.33% (n=1) case of unsatisfactory result and 3.33% (n=1) case of failure due to non-union of ulna.

The results of our series are comparable to the previous studies.

Unsatisfactory result was seen in a male patient with comminuted fracture. The patient was uncooperative where he didn't follow physiotherapy properly.

8. Complications

In our series we had 2 cases of superficial infection. The wound was debrided and pus sent for culture. They resolved with appropriate antibiotics.

Posterior interosseous nerve palsy was noted after surgery in one case where proximal radius was approached through dorsal Thompson approach. Patient was treated conservatively and there was resolution of the nerve injury by two and a half months.

We had noted one case of non-union of ulna fracture which was treated by open reduction and internal fixation with 3.5mm DCP & bone grafting.

9. Duration of Follow Up

Anderson *et al.* had a follow up ranging from 4 month to 9 years with an average of 3 years. Moed in his series followed patients from 12 months to 9 years with an average of 3 years. Chapman series had follow up which ranged from 6 months to 48 months with average of 12 months.

We had a follow up which ranged from 6 months to 24 months with an average of 12 months, which is comparable to Chapman series, but other series had longer follow up.

Conclusion

Based on our experience, we conclude that the treatment of displaced fractures of shaft of both bone of forearm is primarily operative. The closed reduction and cast immobilization for displaced fractures should only be taken if there is any specific contra indication to the operative treatment.

Open reduction and internal fixation with dynamic compression plate is the gold standard treatment for diaphyseal fractures of both bone of forearm. Plate fixation gives a high rate of union, low rate of complications, and satisfactory return of rotations of forearm. It allows early functional motion of elbow and wrist and prevents fracture disease. Adherence to AO principles, strict asepsis, proper post operative rehabilitation and patient education are more important to obtain excellent results. Excellent results with this mode of treatment have been reported in many series of studies, including the present study.

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