Section: Orthopaedics

Original Research Article

ROLE OF DYNAMIC COMPRESSION PLATE IN TREATMENT OF FRACTURE BOTH BONES OF FOREARM

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Received : 21/10/2023
Received in revised form : 01/12/2023
Accepted : 14/12/2023

Keywords:
Forearm fractures, Open reduction, Internal fixation, Diaphyseal fractures, Dynamic compression plates, Bone union.

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DOI: 10.47009/jamp.2023.5.6.203

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (6); 994-998

Abstract

Background: The incidence of forearm fractures is increasing due to population growth, vehicle usage, industrialisation, violence, and sports activities. This study aimed to evaluate the results of open reduction and internal fixation of diaphyseal fractures in both forearm bones using dynamic compression plates. **Materials and Methods:** This prospective time-bound study involved 20 consecutive cases of fractures of both forearm bones by open reduction and internal fixation with 3.5 mm AO-DCP between May 2010 and October 2012 at Rajah Muthiah Medical College and Hospital, Annamalai University. Chidambaram. The patient underwent surgery, which involved a Dorsal Thompson incision, a Volar Henry approach, and a minimum of five cortices. The follow-up was performed until June 2012. **Result:** A study of 20 patients aged 16-60 found that fractures were most common in 2-3 decades and had an average age of 34.6. 13 (65%) had a right forearm fracture, and seven patients (35%) had a left forearm fracture. Most fractures (70%) occurred in the mid-diaphysis. The duration of surgery ranged from 60 to 95 min, with an average time of 80 min. Eighteen patients (90%) had a sound union within <6 months. Of the 20 patients, 17 (85%) showed excellent results, two (10%) showed satisfactory results, and one (5%) showed unsatisfactory results. **Conclusion:** AO-DCP is the preferred implant for closed displaced diaphyseal fractures of both forearm bones because of its stable fixation, early bone union, and efficient internal fixation. It minimises complication rates, allows immediate mobilisation, and provides excellent functional results.

INTRODUCTION

Forearm fractures are increasing faster than predicted due to the increased population, increasing number of vehicles, rapid industrialisation, increased incidence of violence, and various sports activities.[1] These factors have contributed to increased fracture shafts in both forearm bones. The forearm represents the critical anatomical unit of the upper limb, permitting the upper limb effector organ to perform multiaxial daily activities. These bones form five joints: Ulno-humoral, Radio-humoral, proximal radioulnar, distal radioulnar, and radio-carpal articulation.[2,3] The reasons for the high rate of nonunion and malunion, as well as poor functional outcomes, are the complex anatomical structure with coordination between muscles, tendons, bones, and joints, which are responsible for the multifold functions of the arm and hand, including Pronation and Supination, where the radius rotates around the ulna.[4]

The radial bow should be maintained to achieve good functional outcomes. Retaining the bone length, good opposition, and alignment without malrotation are important factors. Conservative treatment has resulted in malunion, nonunion, synostosis, and, ultimately, poor functional outcomes.[5,6] The dynamic compression plate negates torsional, bending, and shear forces and creates compression across fracture sites through specially designed self-compression holes in a dynamic compression plate design, thereby reducing surgical exposure.[7] Hence, this study aimed to evaluate the results of open reduction and internal fixation of diaphyseal fractures in both forearm bones using dynamic compression plates.

MATERIALS AND METHODS

This prospective time-bound study involved 20 consecutive cases treated for fractures of both bones of the forearm by open reduction and internal fixation with 3.5 mm AO-DCP between May 2010 and October 2012 at Rajah Muthiah Medical College and Hospital, Annamalai University, Chidambaram. Institutional ethics committee approval and informed consent were obtained from all patients.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Inclusion Criteria

Patients with closed diaphyseal fractures of both bones of the forearm, fit for surgery, and aged > 16 years were included.

Exclusion Criteria

Patients who were medically unfit for surgery, those who were not willing to undergo surgery, those with open fractures, and those below 16 years of age were excluded.

Upon admission, a careful history was elicited from the patient and attendants to review the mechanism of injury and severity of the trauma. The patients were then clinically assessed to evaluate their general condition. Methodological examination was performed to rule out fractures at other sites. A local examination of the injured forearm for swelling, deformity, and loss of function was performed, and no nerve injuries were observed.

On palpation, abnormal mobility, crepitus, and forearm shortening were observed. Radial artery pulsations, capillary filling, pallor, and paraesthesia at the fingertips were used to assess distal vascularity. Radiographs of the radius and ulna in both anteroposterior and lateral views were obtained. The elbow and wrist joints were included in each view. After the radiographic examination, the fracture was classified, and the pattern was assessed. The limb was immobilised on the elbow Plaster of Paris slab using a sling.

The patient underwent surgery after appropriate investigation to obtain fitness and consent. Tetanus toxoid and prophylactic antibiotics were administered preoperatively. A soap-water enema was administered the previous night and on the morning of the day of surgery. A Dorsal Thompson incision approached the proximal radius, and the Volar Henry approach was used for the middle and distal radii. A narrow 3.5 mm AO-DCP was used, and a minimum of 5 cortices were engaged with screw fixation in each fragment.

Preoperative Planning: After the radiographic examination, the fracture was classified, and the pattern was assessed. After determining the length of the plates, all instruments required, plates, and screws were sterilised. Part preparation was performed before the day of the surgery. Instruments and implants used in limited contact dynamic compression plating for forearm bones including narrow 3.5 mm AO-DCP of varying length, 3.5 mm universal drill guide, 3.5 mm Drill Sleeve system, Drill bits of 2.5 mm and 3.5 mm, Hand drill/Power drill, 3.5 mm counter sink, Tap for 3.5 mm cortex screw, Depth gauge 3.5 mm, 3.5 mm cortical screws of varying sizes, Hexagonal screwdriver, Bending templates, Bending press/pliers, Sharp hook, General instruments like retractors, periosteal elevators, reduction clamps, bone levers etc,. and pneumatic tourniquet. The AO-DCP, 3.5 mm, is available in lengths of 51–155 mm with 4–12 holes.

The patient was placed supine on the operating table, and a pneumatic tourniquet was recommended. For Henry's approach, the arm was placed on an armboard with the elbow straight and the forearm in a supination position. In the Thompson approach, the arm on the arm board, elbow flexion, and forearm were mid-pronated. The arm was placed over the patient's chest using the ulna subcutaneous approach. General anaesthesia was used in nine cases and brachial block in 11.

Operative procedure: The Dorsal Thomson approach was preferred for proximal and distal radius fractures, whereas the Volar Henry's approach was preferred for ulnar fractures. The fractures were identified, cleaned, and reduced using reduction clamps. A plate was applied, and the fracture was fixed if required. The plate was then adapted to the fragment to form an obtuse angle with the fracture near the plate. A screw hole for axial compression was drilled into the fragment to form an acute angle near the plate. A lag screw was inserted for axial compression, and the screw head was moved towards the centre of the plate. The contour between the plate and screw head moved the screw head towards the centre of the plate, moving the fragment in the same direction. Long screws and plates were used for the porotic, comminuted, and small bones. The wound was closed in layers over a suction drain, and a sterile dressing was applied.

Postoperative care

The limb was elevated for 24–48 h, and the patients were instructed to move their fingers and elbow joints. The suction drain was removed after 24–48 h and the wound was inspected 3–4 days postoperatively. Antibiotics and analgesics were administered to the patients until the suture was removed. The suture was removed on ten postoperative days, and radiographs in the anteroposterior and lateral views were obtained.

Physiotherapy

A posterior plaster splint was applied for 2–3 days to ensure comfort. The patient was encouraged to perform active shoulder and hand ROM exercises. Elbow range of motion, supination, and pronation exercises were initiated as soon as remission of pain and swelling of the forearm permitted, usually after 2 to 3 days. Because of the rigidity of the fixation, rapid motion return was expected. Isotonic exercises are essential for excellent outcomes. Physiotherapy helps in fracture union as there is increased blood supply and tethering of muscles to the bone, and soft tissue contracture is avoided. Excellent results were achieved with physiotherapy and rigid fixation.

All the patients were followed up monthly for the first three months and evaluated based on "Anderson et al. scoring system". The follow-up was performed until June 2012. Elbow and wrist movements were noted, and union was assessed radiologically. A fracture was designated as united when a periosteal callus bridged the fracture site, and trabeculation extended across the fracture line. All data are expressed as frequencies and percentages.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

RESULTS

Of the 20 patients, the age ranged from 16 to 60 years, with fracture being the most common in 2 and 3 decades and an average age of 34.6. Seventeen (85%) patients were male, and three (15%) were female. 13 (65%) had a right forearm fracture and seven patients (35%) had a left forearm fracture. Ten (50%) patients had road traffic accidents, 8 (40%) had falls, and only 2 (10%) had assaults.

Most fractures were observed in the mid-diaphysis of the bones. Fourteen (70%) patients had diaphyseal fractures, three (15%) had proximal third fractures, and three (15%) had lower third fractures in both forearm bones [Table 1].

Most (62.5%) of the fractures were transverse/short oblique. Approximately 35% of fractures were comminuted, and only 2.5% of segmental fractures were present. Four (20%) patients had associated injuries. Eleven of the 20 patients underwent surgery under general anaesthesia, and brachial block was used in the other nine patients. The Dorsal Thompson approach for the radius was used in 17 patients, and Volar Henry's approach was used in three patients. The ulna was approached subcutaneously, and a pneumatic tourniquet was used in all cases. The follow-up period ranged from five to 24 months.

The duration of surgery ranged from 60 to 95 minutes, with an average time of 80 minutes. The tourniquet time ranged from 40 to 60 minutes, averaging 49 minutes. The fracture was considered united when there were no subjective complaints and radiologically when the fracture line was not visible. These fractures healed after six months without an additional operative procedure and were considered to have delayed union. Fractures that did not unite after six months or required an additional operative procedure to unite were considered nonunion.

Eighteen (90%) patients had a sound union in <6 months, and 2 (10%) patients had delayed interosseous union. There were no intraoperative complications. Postoperative complications: Two patients developed superficial infections. The infection was controlled with appropriate antibiotics after the culture and sensitivity reports.

Immediately postoperatively (proximal radius fracture fixation), the patient developed a transient posterior interosseous nerve injury. The patients were treated with a static cockup splint and recovered within approximately six weeks. One patient developed proximal radioulnar synostosis, which resulted in poor functional outcomes. Of the 20 patients, 17 (85%) showed excellent results, two (10%) showed satisfactory results, and one (5%) showed unsatisfactory results [Table 2].

Table 1: Demographic data of the study

		Frequency	Percentage
Sex	Male	17	85
	Female	3	15
Age group	16-20	3	15
	21-30	6	30
	31-40	5	25
	41-50	5	25
	51-60	1	5
Side affected	Right	13	65
	Left	7	35
Mode of injury	RTA	10	50
	Fall	8	40
	Assault	2	10
Level of injury	Middle third fractures	14	70
	Proximal third fractures	3	15
	Lower third fractures	3	15
Associated injury	Fracture femur (Rt)	1	5
	Fracture BB (Rt) leg with fracture radius (Rt)	1	5
	Fracture ulna on the opposite side	1	5
	Ribs (Lt) side	1	5

Table 2: Duration of fracture union, complications, and results

		Frequency	Percentage
Duration of fracture union	<4 months (16 weeks)	12	60
	4-6 months (16-24 weeks)	6	30
	Six months-1 year (24-36 weeks)	2	10
Complications	Superficial infection	2	10
	Posterior interosseous nerve injury	1	5
	Radio-ulnar synostosis	1	5
Results	Excellent	17	85
	Satisfactory	2	10
	Unsatisfactory	1	5

DISCUSSION

The present study was undertaken to determine the efficacy of AO-DCP in treating fractures in both forearm bones. Twenty patients with fractured bones of the forearm were treated with open reduction and internal fixation using a 3.5 mm AO-DCP. We evaluated and compared our results with those

ISSN (O): 2687-5365; ISSN (P): 2753-6556

obtained in other studies that utilised different treatment modalities. In the present study, fractures were common in the second and third decades of life, with an average age of 34.6 years (18-60 years). Our findings are comparable to the study by Moed et al., who found that the average age of the patients was 22 years.8 A study by Chapman et al. showed an average age of 33 years (13-79).9 Schemitsch and Richard found an average of 24 years (16-33).[10]

In a study by Nevile and Charnley, 69.04% were males, and 30.67% were females.[11] Dodge and Cady's study, about 39% were males, and 11% were females.[12] Chapman noted about 78% of males and 22% of females.[9] Carr et al. had 67% males and 33% of females.[13] In our study, male preponderance, with 85% male and 15% female patients, was comparable to that reported in previous studies. In most studies, males were affected more.

In our study, RTA (50%), falls (40%), and assault (10%) occurred. Moed et al. accounted for 50% of the cases of RTA and 20% of the cases due to industrial accidents. 14% due to falls, 12% due to direct blows, and 4% due to gunshot injuries.8 Grace and Eversmann noted about 29 (45%) of patients with automobile motorcycle accidents, 14 (22%) in falls, 2 (3%) had gunshot wounds, and the remainder had other miscellaneous types of injuries.[14]

Nevile and Charnley reported an approximately 50% incidence of fractures in both bones of the right forearm.11 Chapman MW reported about 5.5% incidence of fractures of both bones in the right extremity.9 In our study, we accounted for approximately 65% incidence of fracture of both bones in the right extremity and 35% in the left extremity due to right-hand dominance, comparable to previous studies. However, it is difficult to determine the exact sequence of events in the RTA or fall. Chapman et al. noted that approximately 53% of fractures were comminuted, and 47% were transverse and short oblique fractures.[9] The present study accounted for 62.5% of transverse short oblique fractures, 35% comminuted fractures, and 2.5% segmental fractures. The results were not comparable to those of previous studies, which can be attributed to the low-velocity trauma in our country.

In our study, 70% of the fractures occurred in the middle third, 15% in the proximal third, and 15% in the lower third. Sarmiento et al. noted that 84.6% of fractures in both bones were in the middle third, and 15.4% of cases had a lower third fracture.15 Dodge and Cady documented 71.5% fracture on both bones in the middle third, 21.5% in the distal third and 7% in the proximal third.[12] Chapman MW et al. noted 59% and 40% of fractures in the middle third of the radius and ulna, 13% and 21% in the proximal third of the radius and ulna, and 28% and 12% in the lower third of the radius and ulna, respectively.[9] In all reported studies, the fracture incidence was highest in the middle third and lowest in the proximal third.

Anderson et al. reported 2.9% of superficial infection, 2.9% of nonunion, 2% post-interosseous nerve injury, and 1.2% of radio-ulnar synostosis.[16] Chapman et al. reported 2.5% superficial infections, 2.3% nonunions, 1.5% post-interosseous nerve injuries, and 2.3% radioulnar synostosis.[9] In the present study, there were two cases of superficial infection. They were treated with appropriate antibiotics and the wounds healed without complications. Posterior interosseous nerve palsy was observed in one patient. This case was treated conservatively, and the nerve injury resolved spontaneously. Herein, we present a case of proximal radioulnar synostosis. We believe this complication is related to the fracture level and the communication degree.

Our study had an average union time of 14.2 weeks, 8–28 weeks). We observed 100% union of both the radius and the ulna. The results of the present study are comparable to those of the previous studies. Chapman et al. reported 12 union times (weeks), 6-14 range (weeks), and 98% union.[9] Leung et al. reported 17 union times (weeks), 5-36 range (weeks), and 100% union.[17] McKee et al. reported 10.7 union times (weeks), 5-18 range (weeks), and 97.3% union.[18] In most reported studies, it is usually around 12 weeks, except in the study by Anderson et al., who reported a union time of 7.4 weeks (average).[16] The time for union varies according to age, general condition, rigidity of fixation, and presence of infection. In addition, there was inter-observer variation in the time of union. The absence of tenderness at the fracture site and disappearance of the fracture line with callus formation was considered union. Anderson's criteria for evaluating unions were also considered.

Fracture union and range of movement are two factors that affect functional outcomes. Therefore, early mobilisation prevents soft tissue contracture and muscular tethering and improves vascularity. Anderson et al.'s scoring system was used to measure the functional outcome. In the present study, 17 (85%) patients had excellent results, 2 (10%) had satisfactory results, and 1 (5%) had unsatisfactory results. Anderson et al. reported about 54 (50.9%) cases as excellent, 37 (34.3%) were satisfactory, 12 (11.3%) were unsatisfactory, and 2 (2.9%) were failures.[16] Chapman et al. reported that 36 (86%) cases were excellent, 3 (7%) were satisfactory, 1 (2%) was unsatisfactory, and 2 (5%) were failures.9

Moed et al. reported a follow-up period of 12 months to 9 years, with an average mean of 3 years.8 Chapman et al. reported a follow-up that ranged from 6 months to 48 months with an average mean of 12 months.[9] Anderson et al. reported a follow-up that ranged from 4 to 9 years with an average mean of 3 years.16 Our study had a follow-up ranging from 5 to 24 months with an average mean of 12 months, comparable to the Chapman study; however, other studies had longer follow-ups. In our study, the duration of surgery ranged between 50 and 90 min, with an average of 74.5 minutes. The tourniquet time ranged from 40 to 60 minutes, averaging 49.75 minutes. These findings could not be compared with previous studies' findings, as no data were available.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

CONCLUSION

AO-DCP facilitates stable fixation of the bone and early bone union. It is easier to apply to comminuted, segmental, and short-oblique fractures. Separate incisions for the radius and ulna and preservation of the natural radius curves decreased the complication rate. Rigid fixation of fractures after perfect anatomical reduction with 3.5 mm AO-DCP and screws allows immediate mobilisation. A minimum of five cortices must be fixed in each fracture fragment, and the screw nearest to the fracture line should be at least 1 cm away. This minimises vascular damage to the plated bone segment, leading to a more versatile and efficient application of internal fixation.

With more stable fixation and good compression at the fracture site through screw placement, early union occurs, and postoperative osteoporosis does not occur as early mobilisation is initiated. Postoperative plaster is seldom required for uncomplicated fractures, and early return to light work is possible. It provides excellent functional results for most patients. Complications after well-performed surgeries are minor and easily correctable. Although various implants, such as LC-DCP and PC fixators, may have come, AO-DCP is the implant of choice for all closed displaced diaphyseal fractures of both forearm bones.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556