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A Study of Surgical Management of Fracture Both Bones Forearm in Adults with Limited Contact Dynamic Locking Compression Plate and Screws

Dr. Prasad Veeragandham[1], Dr. Subarna Misra[2*]
[1]Professor, Department of Orthopedics, ICARE Institute of Medical Sciences and Research, Banbishnupur, Purba Medinipur, Haldia, West Bengal 721645, India
[2]Associate Professor, Department of Orthopedics, ICARE Institute of Medical Sciences and Research, Banbishnupur, Purba Medinipur, Haldia, West Bengal 721645, India

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***Corresponding author**
Dr. Subarna Misra

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Abstract: Forearm fractures characterize most injuries. Thus, effective management of forearm fractures requires an understanding of the anatomy as well as the function of the ulna, radius, interosseous membrane, distal and proximal radioulnar joints. Plate fixation is the most commonly used technique for the treatment of shaft fractures of both forearm bones. However, all fractures are difficult to treat with plate fixation because of soft tissue injuries, fracture patterns, or the patient's condition. The present study was done from January 2016 to December 2016 which consists of 25 cases of fracture both bones of the forearm. All the cases were openly reduced and internally fixed with 3.5mm LCP. Proximal radius was approached by dorsal Thompson incision and volar Henry approach was used for middle and distal radius. A narrow 3.5mm LCP was used and a minimum of 6 cortices were engaged with screw fixation in each fragment. All the patients were followed up at monthly intervals for first 3 months and evaluation was done based on "Anderson et al" scoring system. Elbow movements and wrist movements were noted and the union was assessed radiologically. The age of these patients ranged from 18-80 years with fracture being most common between 18-40 yrs age group (52%), followed by 41-60 yrs age group (36%) and an average age of 32.8 years. Out of 25 patients, 20 patients (80%) were males and 5 patients (20%) were females showing male preponderance because of working in factories, fields, travelling and sports and bikers having road traffic accidents [Table 1]. Mode of injuries were noted as direct blow, fall on an outstretched arm, often during sports or from a height and road traffic accidents or automobile/motorcycle accidents 12%, 36% and 52% respectively. In conclusion, at the end of their study that open reduction and internal fixation of adult forearm shaft fractures using small Dynamic Compression Plate was associated with a high rate of success. Results with this type of plate are comparable with the newer and more expensive implants. Open reduction and internal fixation helps in perfect fracture reduction, rigid fixation, better bone healing and early mobilization, the normal functions of the hand can be achieved at the earliest.

Keywords: Forearm, diaphyses, fracture, internal fixation, dynamic locking compression plate, outcomes.

INTRODUCTION

The forearm is a complex anatomic structure serving an integral role in upper-extremity function. The dexterity of the upper limb depends on a combination of hand and wrist function and forearm rotation. The forearm consists of two parallel bones (radius and ulna) and radioulnar joints of the elbow and wrist, which play an important role in forearm rotation. Shaft fractures involving these bones, if inadequately treated, can result in a significant loss of motion of the forearm [1]. Forearm plays a cardinal role in the function of upper extremity. Fractures involving both bones of forearm have been acknowledged as articular fractures as even minor aberration in the spatial orientation of radius and ulna can appreciably debilitate the performance of hand [2].

The most common causes of forearm fractures include:

- Direct blow
- Fall on an outstretched arm, often during sports or from a height
- Automobile/motorcycle accidents

A broken forearm usually causes immediate pain. Because both bones are usually involved, forearm fractures often cause an obvious deformity. Forearm fractures can cause further injury and complications. The ends of broken bones are often sharp and can cut or tear surrounding blood vessels or nerves. Excessive bleeding and swelling right after the injury may lead to acute compartment syndrome, a condition in which the swelling cuts off blood supply to the hand and forearm. It typically occurs within 24 to 48 hours of the injury and causes severe pain when moving the fingers. Compartment syndrome can result in loss of sensation and function, and requires emergency surgery once it is diagnosed. In such cases, the skin and muscle coverings are opened and left open to relieve pressure and allow blood to return. Open fractures expose the bone to the outside environment. Even with good surgical cleaning of the bone and muscle, the bone can become infected. Bone infection is difficult to treat and often requires multiple surgeries and long-term antibiotics [3].

The basic principles of an internal fixation procedure using a conventional plate and screw system (compression method) are direct, anatomical reduction and stable internal fixation of the fracture. Wide exposure of the bone is usually necessary to gain access to and provide good visibility of the fracture zone to allow reduction and plate fixation to be performed. LCP (Locking compression plate) is a product of these combinations and is in line with the latest plating techniques, the aim of which is to achieve the smallest surgical incision and to preserve blood supply to the bone and adjacent soft tissues and stability at the fracture site. The development of the Locking Compression Plate (LCP) has only been possible based on the experience gained with the PC-Fix and LISS. The LCP with combination holes can also be used, depending on the fracture situation, in either a conventional technique (compression principle), bridging technique (internal fixator principle), or a combination technique (compression and bridging principles). A combination of both screw types offers the possibility to achieve a synergy of both internal fixation methods [1, 4].

In this study, plate fixation was considered as the first option for all shaft fractures of the radius and ulna. If it was not possible to perform plate fixation of both the radius and ulna due to the patient's condition, fracture of one bone was treated with plate fixation and fracture of the other bone was treated with IM nail fixation.

This type of plate fixation relies on the threaded plate-screw interface to lock the bone fragments in position and do not require friction between the plate and bone as in conventional plating. The present study was undertaken to evaluate the use of LCPs in fractures of forearm bones.

MATERIALS & METHODS

The present study includes treatment of 25 cases of fracture both bones of forearm by open reduction and internal fixation with 3.5 mm LCP done between January 2016 to December 2016 at a tertiary care teaching hospital, Purba Medinipur, West Bengal.

Inclusion Criteria

- Patients with diaphyseal fractures of both bones of forearm
- Patients above the age of 18 years
- Patients fit for surgery

Exclusion Criteria

- Compound fractures of forearm bones
- Patients not willing for surgery
- Patients medically unfit for surgery

On admission of the patient, a careful history was elicited from the patient and/or attendants to reveal the mechanism of injury and the severity of trauma. The patients were then assessed clinically to evaluate their general condition and the local injury. In general condition of the patient the vital signs were recorded. Methodical examination was done to rule out fractures at other sites. Local examination of injured forearm revealed swelling, deformity and loss of function. Any nerve injury was looked for and noted.

Palpation revealed abnormal mobility, crepitus and shortening of the forearm. Distal vascularity was assessed by radial artery pulsations, capillary filling, pallor and paraesthesia at finger tips. Radiographs of the radius and ulna i. e., anteroposterior and lateral views, were obtained. The elbow and wrist joints were included in each view. The limb was then immobilized in above elbow Plaster of Paris slab with sling. The patient was taken for surgery after routine investigations and after obtaining fitness towards surgery. The investigations are as follows: Hb%, Urine for sugar, FBS, Blood urea, Serum creatinine, HIV, HBSAg and ECG. Proximal radius was approached by dorsal Thompson incision and volar.

Henry approach was used for middle and distal radius. A narrow 3.5mm LCP was used and a minimum of 6 cortices were engaged with screw fixation in each fragment.

OPERATIVE PROCEDURE

General anaesthesia was used in 12 cases and brachial block in 8cases. Pneumatic tourniquet was applied and time noted. Painting and draping of the part done. The Radius was approached using either dorsal Thompson/Volar Henrys approach. For proximal radius and mid shaft fractures, dorsal Thompson approach was preferred and for distal radius fractures Volar Henry's approach was preferred. Ulna was approached directly

over the subcutaneous border. The bone which was less comminuted and more stable was fixed first and later the other bone was fixed. After identifying the fracture ends, periosteum was not 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. A plate of at least 6 holes was chosen and longer plates were used in spiral, segmental and comminuted fractures**.** For upper third radial fractures, the plate was fixed dorsally. For middle third, the plate was fixed dorsolateral and for distal radial fractures the plate was fixed on the volar aspect. In ulnar fractures, plate was applied over the posterior surface of ulna [5].

After treatment

Postoperatively a crepe bandage was applied over the affected forearm and arm pouch was given. The patient was instructed to keep the limb elevated and move their fingers and elbow joint. Suction drain was removed after 24-48 hours. Wound was inspected after 3-4 days postoperatively. Antibiotics and analgesics were given to the patient till the time of suture removal. Suture/staples removed on 10th postoperative day and check X-ray in Anteroposterior and lateral views were obtained.

All the patients were followed up at monthly intervals for first 3 months and evaluation was done based on "Anderson et al" scoring system [6]. Elbow movements and wrist movements were noted and the union was assessed radiologically. The fracture was designated as united when there was presence of periosteal callus bridging the fracture site and trabeculation extending across the fracture line.

RESULTS

The present study was done from January 2016 to December 2016 which consists of 25 cases of fracture both bones of the forearm. All the cases were openly reduced and internally fixed with 3.5mm LCP.

Table-1: Demographic and clinical characteristics of study participants [n=25]

Characteristics	No. of Patients	Percentage (%)
Age [in yrs]		
18-40	13	52
41-60	9	36
61-80	2	8
>80	1	4
Sex Distribution		
Male	20	80
Female	5	20
Side Affected		
Right forearm	14	56
Left forearm	10	40
Both sided forearm	01	4
Mode of Injury		
RTA [Automobile/motorcycle accidents]	13	52
Fall on an outstretched arm, often during sports or from a height	9	36
Direct blow	3	12
Level of Fracture		
Proximal Third	5	20
Middle Third	12	48
Distal Third	8	32
Total	25	100

The age of these patients ranged from 18-80 years with fracture being most common between 18-40 yrs age group (52%) followed by 41-60 yrs age group (36%) and an average age of 32.8 years [Table 1]. Out of 25 patients, 20 patients (80%) were males and 5 patients (20%) were females showing male preponderance because of working in factories, fields, travelling and sports and bikers having road traffic accidents [Table 1]. Mode of injuries were noted as direct blow, fall on an outstretched arm, often during sports or from a height and road traffic accidents or automobile/motorcycle accidents 12%, 36% and 52% respectively.

All the fractures were closed injuries. Majority of the fractures were seen in the mid-diaphysis of both bones of forearm 12 (48%), followed by distal third fracture 8 (32%) and proximal third fracture 5 (20%) of both bones of forearm [Table 1].

Table-2: Type of the forearm fracture and associated injuries among study participants [n=25]

Type of fracture	Radius	Ulna
Transverse/short oblique	15 (60%)	16 (64%)
Comminuted	7 (28%)	6 (24%)
Segmental	3 (12%)	3 (12%)
Total	25	25

On an average 62% of the fractures were transverse/short oblique. About 26% of fractures were comminuted and only 12% of segmental fractures were present [Table 2]. About 12 (48%) cases of forearm both bone fracture patients had associated injuries [Table 3].

There were 2 patients in the study group who had associated head injury, 3 patients had ipsilateral fracture shaft humerus and 3 patients had associated olecranon fracture.

Table-3: Type of associated injuries among study participants [n=25]

Associated injuries	No. of cases	Percentage
Closed head injury	2	8%
Unilateral pubic bone fracture	1	4%
Olecranon fracture	3	12%
Fracture of both bones of leg	1	4%
Ipsilateral fracture shaft humerus	3	12%
Rib fracture	2	8%
Total	10	40%

Table-4: Time taken for fracture union

Time of union	No. of patients	Percentage
<16 weeks	17	68
16-24 weeks	6	24
More than 24 weeks	1	4
Non union	1	4
Total	25	100

The fracture was considered as united when there were no subjective complaints, radiologically when the fracture line was not visible. It was found out in our study that there was 96% union of the fractures and one case there was non-union due to other pathological reasons [Table 4]. About 17 (68%) of the patient had union within 16 weeks; followed by 24% between 16 to 24 weeks and 4% of cases it took more than 24 weeks..

Table-5: "Anderson" *et al.* scoring system [6] criteria for evaluation of results

Results	Union	Flexion/Extension at elbow joint	Supination and pronation
Excellent	Present	<10° loss	<25% loss
Satisfactory	Present	<20° loss	<50% loss
Unsatisfactory	Present	>20° loss	>50% loss
Failure	Non-union with or without loss of motion		

Using the Anderson et al scoring system we had 19 (76%) patients with excellent results, 3 (12%) patients with satisfactory results and 2 patients (8%) unsatisfactory results. Unsatisfactory results may be due to misalignment. One case reported failure of due to additional pathological reason [Table 6]. The functional outcome was assessed according to Anderson scoring system which included evaluation of the movements and the radiological union.

Table-6: Treatment outcome with limited contact dynamic locking compression plate

Results	No. of patients	Percentage
Excellent	19	76
Satisfactory	3	12
Unsatisfactory	2	8

Failures	1	4

Table 7: Complication after limited contact dynamic locking compression plate

Complications	No. of patients	Percentage
Stiffness	3	12%
Superficial infection	2	8%
Posterior interosseous nerve injury	1	4%
Total	6	24%

In our study group 4 patients developed complications post surgery. In our study 2 patients (8%) encountered with superficial infections postoperatively which was treated with antibiotics. The infection subsided after the treatment. Three patients (12%) had stiffness of the elbow and the wrist joint which was treated with regular physiotherapy [Table 7].

DISCUSSION

Fractures of both bones of the forearm are usually classified according to the level of fracture, the pattern of the fracture, the degree of displacement, the presence or absence of comminution or segment bone loss, and whether they are open or closed. Each of these factors may have some bearing on the type of treatment to be selected and the ultimate prognosis [7]. Disruption of the proximal or distal radioulnar joints is of great significance to treatment and prognosis. Determining whether the fracture is associated with joint injury is imperative because effective treatment demands that both the fracture and the joint injury be treated in an integrated fashion [8, 9].

The mechanism of injury is variable. The most common cause is a direct blow to the forearm, producing a single (nightstick) fracture of the ulna, the radius, or both. The next most likely mechanism is a fall on an outstretched hand with the forearm pronated. Other mechanisms of injury include road traffic accidents and athletic injuries. The force generated is usually much greater than that required to cause a Colles fracture. Most forearm shaft fractures resulting from falls occur in athletes or in persons who fall from heights [8].

Study by Ranganath HD *et al*. found out that there was a predominance of male patients 66.7% and the female population was found to be 33.3% which was comparable with other studies [10]. Study by Ranganath HD *et al.* found that there was an incidence of 53.4% fractures in the middle1/3, 23.3% fractures occurred at the proximal 1/3 and 23.3% fractures at the distal1/3. Similarly in the ulna transverse fracture of the ulna was most common which accounted to 40% of the fractures [10].

The dynamic compression plate (DCP) was developed in 1969 by Perren[11] and used successfully in humans by Allgower *et al*. [12, 13]. Its spherical geometry not only allowed self compression but also enabled the maintenance of a congruent fit between the screw and the plate hole at different angles of inclination. Thus, the plate was more adaptable to different situations of internal fixation and could fulfill all the different plate functions [11]. Burwell H N *et al*. study [14], studied outcome of treated forearm fractures in adults using plates. They believed that plate fixation as the most satisfactory treatment for forearm fractures and can achieve good functional results with avoidable complications.

Study by Anderson LD *et al*. [15], noted that 244 patients with 330 diaphyseal fractures of radius and ulna which were treated with ASIF compression plates. The overall union rate was 97.9% for the radius and 96.3% for the ulna. They achieved excellent functional results in acute diaphyseal fractures of forearm and advised minimal stripping of periosteum before plate application.

Allgower M *et al*. study, which was consisted of 1903 radial shaft fractures, 666 ulnar shaft fractures, for 97% cases narrow DCP was used. They noted that there were 3.2% non-union and rest of them had good functional outcome. They recommended the 3.5mm DCP for fixation of forearm fractures. Mullaji AB *et al*. [12] study16, authors in their treatment of 9 clavicle fractures with 3.5mm LC-DCP is a superior device endowed with several technical advantages which makes it an ideally suited implant for satisfying the unique anatomical and biomechanical requirements of internal fixation of the clavicle.

Uhthoff HK *et al*. study [17], authors were carried a trial comparing the LC-DCP with PCFix for forearm fractures. Their study concluded plating as the best method of fixation for diaphyseal fractures of the forearm. Despite the differences in the concept of fracture fixation, these two implants appear to be equally effective for the treatment of diaphyseal forearm fractures. The prognosis for adults with fractures of the radius and ulna depends on many factors [18-21]. However, the factors under the surgeon's control include choice of treatment method, timing of internal fixation in open fractures, soft-tissue handling, and restoration of osseous anatomy. Anderson reported a union rate of 97.3% for fractures treated with open reduction and internal fixation (ORIF) using compression plates [9]. Of these patients, 90% had satisfactory or excellent function, and only 10% had

unsatisfactory or poor function. Sage reported a union rate of 93.8% for fractures treated with triangular nails [22].

A study (56 cases) by A S Rao *et al*. showed excellent results were obtained (75 %, 42 cases), good (12.5%7), fair (12.5%,7) with one infection and delayed union each when fixed with DCP[23]. A study conducted by KC Saikai the year 2006 to 2009 showed excellent functional outcome in 89%, satisfactory 8% and poor in 1% of patients [24]. A study conducted by Marya km 1996 to 2000 showed excellent results in 88%, satisfactory in 7%, unsatisfactory in 4% and failure in 1% [25]. Muralidhar BM *et al*. revealed the final outcomes using the Anderson *et al.* scoring system we had 26 (81%) patients with excellent results, 6 (19%) patients with satisfactory results. There were no cases of intraoperative complications. To obtain excellent results: proper preoperative planning, minimal soft tissue dissection, adherence to AO principles, strict asepsis, proper postoperative rehabilitation and patient education are mandatory [26].

Locking compression plate (LCP) was devised by combining the features of a LC-DCP and a PC-Fix [27]. Theoretically, this allows for more rapid bone healing besides decreasing infection, bone resorption, delayed union/non-union and secondary loss of reduction [28]. But reports on the results of clinical application of LCP are few, especially on its efficacy, or superiority over other plates in the treatment of diaphyseal fractures of forearm bones [29-32]. Hence, we considered it worthwhile to conduct a comparative study to assess the superiority of LCP over LC-DCP, if any, in the treatment of fractures of both bones of forearm. The limitation of this study is small sample size study from a single center hence significant conclusions could not be drawn.

CONCLUSION

The present study was conducted to assess the outcome of LCP plating in fractures of both bones forearm. These fractures have to be fixed as early as possible and it is important to achieve anatomical reduction and stable internal fixation for excellent functional outcome.

It is essential to regain length, apposition, axial alignment and normal rotational alignment while treating diaphyseal fractures of the radius and the ulna to gain good range of pronation and supination. The chances for the occurrence of malunion and non-union are greater because of the difficulties in reducing and maintaining the reduction of two parallel bones in the presence of the pronating and supinating muscles, which have angulatory as well as rotatory influences. Open reduction and internal fixation with plating is generally accepted as the best method of treatment for displaced diaphyseal fractures of the forearm in the adult. LC plating is an effective treatment option for fractures of both bones of forearm. The outcome is determined by using proper principles of plating.

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