Original Article

Outcome of Dynamic Compression Plate for Displaced Diaphyseal Fractures of the Radius and Ulna in Adults

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Abstract

Background: In adults displacement, angulation, rotation and comminution may be quite marked and closed reduction is often difficult or impossible to achieve. Even if an acceptable position can be obtained, and a cast successfully applied, late slipping of the fracture is extremely common and difficult to treat with severe loss of function. **Objective**: To assess the fracture union and functional outcome of patients treated with stable internal fixation and early mobilization. **Study Design:** Prospective study. **Setting**: Orthopaedic surgery departments of Independent Medical College and Punjab Medical College Faisalabad. **Study Period**: Between January 2010 and December 2011. **Method**: The study group included 32 males and 14 females aged 14-60 years with unstable displaced fractures shaft radius, ulna or both. Relevant history and x-rays of the forearm were taken. We followed the inclusion and exclusion criteria. All the cases were treated with open reduction and internal fixation with 3.5mm small fragment dynamic compression plate and screws. The cases were followed for at least 6 months. Patients were assessed functionally and radiologically and results were graded according to the system described by F.M. Marek et al (1961) as excellent, good, fair and poor. **Results**: This prospective study was completed on 46 patients 32 were male and 14 were female. All fractures were united in acceptable alignment. At final assessment excellent results were obtained in 31 (67.39%), good results in 8 (17.39%), fair in 4(08.69%) and poor in 3(06.53%) of the cases. Poor clinical out come was high in neglected and mishandled cases. There was no implant breakage or failure or fracture adjacent to 3.5 mm small fragment DCP. **Conclusion**: Dynamic compression plate is an excellent fixation for displaced diaphyseal fractures of the forearm bones in adults. **Key words**: Diaphyses; forearm; fracture; internal fixation; Dynamic compression plate; radius; ulna.

INTRODUCTION

We deal with lot number of polytrauma and fractures of the forearm bones. The perfect union of radius and ulna and normal movements of forearm serves as positioning the hand in space which is important to all of us in the usual activities of daily living[1]. Accurate initial management is required after fractures of the shafts of the radius and ulna if function is to be restored[2]. The decision regarding which treatment is best is influenced by many variables (patient age, degree of soft tissue injury, fracture configuration, patient size and activity level, anticipated client compliance, etc)[3]. The AO compression plating apparatus seemed to satisfy the basic objectives of internal fixation; namely (1) anatomical reduction (2) preservation of vascularity (3) mechanically stable fixation and (4) rapid mobilization of the joints in proximity. Early active pain-free mobilization of muscles and joints adjacent to the fracture prevents the development of fracture disease[4]. A diaphyseal forearm non-union is disabling as it affects not only the forearm but also the elbow and wrist. Failure to reconstitute the exact relation between radius and ulna will affect the proximal and distal joints, limiting the ability to place the hand in space[5].

It is difficult to achieve a satisfactory closed reduction of displaced fractures of the forearm bones, and if achieved, it is hard to maintain[6]. In this study we evaluated treatment outcomes after open reduction and internal fixation with 3.5 mm small fragment Dynamic compression plate.

INCLUSION CRITERIA

Failure of conservative treatment
Untreated with unacceptable conditions for delayed surgery
Patients with acute displaced diaphyseal fractures of the radius and ulna
Isolated fracture of the radius or ulna
Both male and female
Age above 14 years and below 60 years
Both upper limbs (forearm bones)

EXCLUSION CRITERIA

Open fractures in order to avoid insertion of implant into potentially infected tissue.
Polytrauma
Pathologic fractures of the forearm bones.
Compartment syndrome
Age group above 60 years
Associated Neurovascular injury
Montaggia Fracture-Dislocations[7]
Galeazzi Fracture-Dislocations

MATERIAL AND METHODS

In this study 53 consecutive patients with severely displaced and unstable diaphyseal forearm fractures were selected from orthopaedic surgery departments of Independent Medical College and Punjab Medical College Faisalabad between January 2010 to December 2011. 3 patients declined surgical treatment in spite of severely displaced fractures. 50 patients were treated by open reduction and internal fixation with 3.5mm small fragment dynamic compression plate (DCP) and screws at the beginning or after redisplacement that occurred during the conservative treatment of cast immobilization or after applying wooden sticks by bone setters. We followed the inclusion and exclusion criteria. Four of these patients (3 male and 1 female) were lost during follow-up before union and therefore excluded from this study. 46 out of 50 were available for follow up. A comprehensive data was collected of all patients with diaphyseal forearm fractures to obtain the following information: patient age, sex, date of injury, mechanism of injury, pain, deformity, swelling and loss of function, including neurovascular status and general survey of the patient. Necessary investigations including x-rays carried out. A minimum of two views (anteroposterior and lateral) were mandatory in all suspected forearm fractures including elbow and wrist joints. Fracture status (open vs. closed), fracture location (proximal 1/3 vs. middle 1/3 vs. distal 1/3), fracture pattern (transverse or oblique), bone involved (both radius and ulna or radius only or ulna only), date of surgery, time to radiographic union, final range of motion (supination and pronation), pain, return of good function, deformity and postoperative complications. The informed consent for surgery was obtained from each patient after the approval of study from ethical review committee Independent Medical College.

SURGICAL TECHNIQUE

After taking all necessary pre-operative measures under general anaesthesia and tourniquet control. Patient in supine position, after scrubbing, painting and draping separate incisions were used for radius and ulna (Fig-1).

RADIUS APPROACH[8]

The radius approached through Henry's anterior approach to entire shaft : A longitudinal incision was begun at a point just lateral and proximal to the biceps tendon along the medial border of brachioradialis extended distally as far as to the radial styloid , in the supinated position of the forearm. The deep fascia of the forearm was divided in line with the skin incision taking care to protect radial vessels. In the proximal part the supinator muscle was stripped subperiosteally from the radius and reflected laterally. The deep branch of the radial nerve was carried with it and was protected. Distally longitudinal incision was made between the structures innervated by the different nerves. Brachioradialis along with identification and protection of the sensory branch of the radial nerve beneath the brachioradialis muscle laterally and flexor carpi radialis tendon with radial artery and vein was mobilized and retracted medially. Now the flexor pollicis longus, flexor digitorum sublimis and pronator quadratus muscles were exposed and elevated subperiosteally from the anterolateral edge of the radius and stripped medially.

II. ULNA APPROACH

Boyd's approach[8].

Since part of the posterior surface of ulna throughout its length lies under the skin, any part of the bone can be approached by incising the skin, fascia and periosteum along this surface. The aponeurotic origins

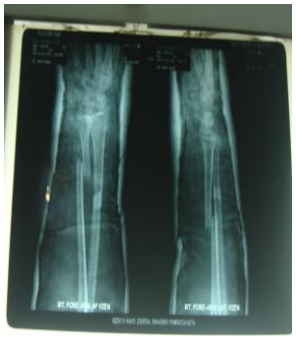
of flexors carpi ulnaris and digitorum profundus retracted medially and that of extensor carpi ulnaris retracted laterally.

PLATE FIXATION (FIG-1)

Fracture was reduced and 3.5mm contoured small fragment DCP plate with 7 holes or having 8 holes was placed on the bone with the wider middle portion over the fracture for fixation of these fractures depending on the bone being fixed and on the quality of the bone. Engaging a minimum six cortices above and below the fracture site; plate was held in position with reduction and plate holding forceps. Drill hole was drilled with the 2.5 mm drill bit with the eccentric drill guide; hole was tapped, and the 3.5 mm cortical screw was inserted but not fully tightened, similarly a loaded screw was inserted in other fragment. Both the screws tightened alternatively. It is rarely necessary for more than two screws to be loaded. Rests of the screws were applied in neutral position. Where needed additional interfragmentary screws were inserted out off or through the plate and a bone grafting if there was any residual gap or if there was no sign of callus by six weeks[9]. The aim was to achieve a rigidity of fixation which will permit early mobilization, preventing the development of fracture disease. With stable / rigid internal fixation, the external immobilization was not required in co-operative patients. Post operative cast protection was given for two weeks in few cases who were not compliant with treatment. Finger and shoulder exercises were encouraged right from the start. All patients were followed up monthly until union; on an average the follow up period of these patients varied from six to twelve months (range: 1 to 24 months).Radiographic assessment was performed at 3, 6 and 12 months. Clinical assessments regarding pain and function were undertaken at follow-up.

Figure-1

A-Pre operative X-rays



B-Anesthesia, position of patient and painting

C-Approch to radius

D-Reduction of fracture radius

E-Fixation of radius with plate

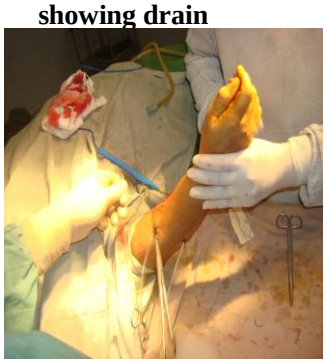
F-Approch to Ulna

G-Reduction of Fracture Ulna

H-Fixation of Ulna with plate

I-Closure of radial side and drain

J-Closure of Ulna side showing drain



K-Postoperative X-rays

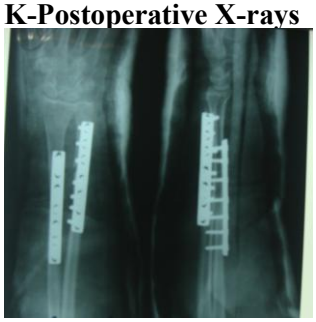


Fig 1: A to K Showing surgical steps of plate fixation for acute diaphyseal displaced unstable fracture right radius and ulna.

At the final follow-up, clinical outcomes were graded according to the system described by F.M. Marek et al (1961) criteria (modified).Table 1 : F.M. Marek et al criteria (modified).

Table-1

Table-1

Results	Anatomical	Functional
1) Excellent	- Anatomical alignment of the fragment where union is achieved in less than six months	Full range to 10^0 limitation of forearm rotations. Full range of elbow flexion and extension. Full range of wrist flexion and extension.
2) Good	- Slight step formation - Angulation not exceeding 10^0 - No rotational deformity	Union of fracture 10 to 20^0 limitation of forearm, elbow and wrist movements.
3) Fair	- Angulation not exceeding 20^0 - Slight rotational deformity	Union of fracture. $20^0 - 40^0$ limitation of forearm, elbow and wrist movements.
4) Poor	- Narrowing of interosseous space	Delayed union or nonunion. 40 to 50^0 limitation of forearm, elbow and wrist movements.

RESULTS

46 cases were completed for final evaluation. 32 patients were males and fourteen were females, Male to female ratio was 2.3:1. The average age of patients treated with plate fixation was 38 years (range: 14 to 60 y). Among them 23 patients had both bone fractures, fourteen patients had isolated fracture shaft radius, nine patients with isolated fracture shaft ulna.

Right side was involved in 30 (65.21%) cases and left side in 16 (34.79%).Fracture in 23 (50.00%) was by road traffic accident, 14 (30.43%) due to fall and sports activities, 7 (15.22%) due to physical assault and 2 (04.35%) due to miscellaneous causes. In most cases the middle third was involved. The average time of surgery was 55 minutes (range 45-75 minutes). The mean follow-up was 6 months (range: 1 to 24 months). The mean time to fracture union was 12.6 weeks (range: 8 to 16 wk). There was a slight trend toward longer times to union in neglected cases. Delayed union occurred in three cases. Two of these patients required bone grafting. 8 patients had superficial wound infection which resolved with dressing and antibiotics. Muscle atrophy and Sudecks dystrophy were present in 2 patients who showed patchy osteoporosis of the carpal bones on x-rays. No distal neurovascular deficit was present in any of the patients. All fractures were united in acceptable alignment. At final assessment excellent results (Fig-2) were obtained in 31 (67.39%), good results (Fig-3) in 8 (17.39%), fair in 4(08.69%) and poor in 3(06.53%) of the cases (Table-2). Poor clinical out come was high in neglected and mishandled cases. There was no implant breakage or failure or fracture adjacent to 3.5 mm small fragment DCP.

Table-2

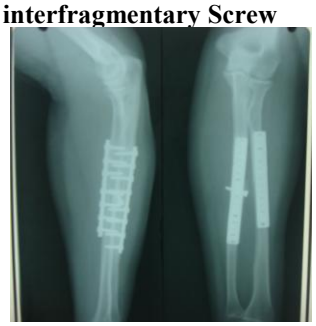
Outcome of 3.5mm dynamic compression plate fixation

Outcome	Number	Percentage
Excellent	31	67.39%
Good	08	17.39%
Fair	04	08.69%
Poor	03	06.53%

A-Preoperative X-rays Operated 4 months after conservative treatment

B-Postoperative X-rays after month operation showing grafting

C-After 1 year post operative nicely Healed bones showing interfragmentary Screw



D-Supination, elbow and Wrist neutral position showing excellent results

E-Pronation with fist formation

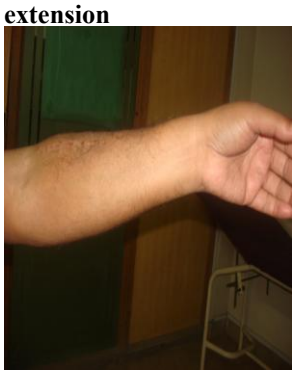
F-Elbow flexion and wrist pamar flexion

Fig 2: A to F Case with Delayed Presentation of Fracture right radius and ulna mid shaft treated by plating, interfragmentary screwing and bone grafting with excellent results.

A-pre operative x-rays

B-Post operative X- ray showing union

C-Supination elbow extension and wrist extension



D-Elbow flexion pronation and wrist pamar flexion

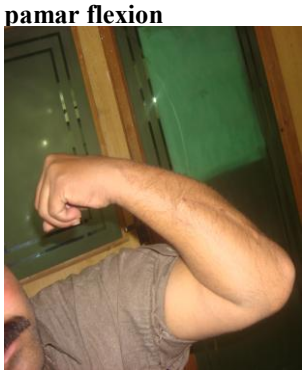


Fig-3: D-Elbow flexion pronation and wrist planter flexion

Fig-3: A to D Acute unstable displaced diaphyses fracture left radius and ulna treated with plating with good results.

DISCUSSION

Management of these fractures varies from application of wooden sticks by bone setters, plaster of Paris (pop) casts, pinning, nailing, and functional bracing to rigid fixation by different plates, interlocked forearm nailing, and external fixation. Proponents of each technique have shown the pitfalls of others[1].

Undisplaced single bone fracture should be treated in a long arm cast until there is roentgenographic evidence of union or definitive evidence of delayed union. If a fracture slips in a well-applied plaster, then the fracture is mechanically unsuitable for treatment by plaster, and another mechanical principle should have been chosen[6]. Unsatisfactory results of closed treatment have been reported to range from 38% to 74%. For this reason, open reduction with internal fixation is routine for displaced diaphyseal fractures in adults[9].

Closed reduction under image and intramedullary nailing with[10] or without[11] interlocking is technically more demanded over plate fixation. The small diameter of the medullary canal does not permit use of large diameter pins to resist displacement loads. We chose not to use this technique and would caution lack of compression and rotational control. The functional outcome of intramedullary nailing indicated inferior results to plate-and-screw techniques. Sage in 1959[12] reported nonunion in 6.2 percent of cases with variety of medullary fixation devices.

There is no role for minimally invasive techniques as limited exposure will likely compromise the ability to obtain anatomic alignment. The present emphasis is on flexible intramedullary nails[13] or contoured K[14] wires which is more effective in children[15].

The external fixator is a good treatment for open, comminuted or special distal diametaphyseal fractures in older children, adolescents and adults[16]. This method seldom provides ideal alignment and extensive at-home care and monitoring of the device is needed. It is suggested in the literature that K-wires, simple lag screws or one-third tubular plates carry a high risk of providing inadequate fixation. Stability of fixation is important in achieving early consolidation[6]. The LCP is an effective bridging device used for treating osteopenic bone, segmental bone loss, or excessive comminution. But for treating simple fractures its superiority over conventional plating is yet to be proven[17,18]. The cost, estimated to be as much as three times for conventional systems, is also a major concern.

The open reduction and internal fixation with 3.5mm DCP can be done as a semi-elective procedure as soon as the patient's condition warrants; reduction is easiest when the fracture is treated within the first 48 hours. Fractures of both bones or a displaced isolated fracture of the radius or ulna should be treated by open reduction, plate fixation, and cancellous bone grafting whenever there is bone loss. Dynamic compression plate provides more secure fixation without cast protection. It produces sufficiently rigid fixation, impaction and compression of the fracture site and also prevents rotational strain which will last for the whole duration of bone healing[19]. Fixation with plates allows early active postoperative motion with excellent functional outcome of the wrist and elbow[20]. This helps prevent muscle atrophy and joint stiffness, which often are responsible for unsatisfactory results. There is no interference with medullary blood supply and there is no external callus formation, therefore there is no encroachment upon the interosseous space.

Most authors advise six cortices on each side of the fracture; more recently use of only four cortices on each side was suggested[21]. The use of 3.5-mm (DCP, LC-DCP, and LCP) plates is preferred over 4.5-mm plates as these are too bulky for the forearm. As evident from the literature, use of 3.5 mm plate systems has nearly eliminated the problem of refracture after plate removal. The results in our study are comparable to Chapman et al[22]. They reported in their series of 87 patients with 129 forearm fractures an excellent or satisfactory functional result in 92% of their patients, a union rate of 97% with an average time to union of 12 weeks (range, 8 to 24 weeks) with 2 delayed union and 2 non-union and an infection rate of 2.3%.In our study union achieved in all cases with a comparable time frame of average time to union being 12.6 weeks. We agree with Solanki et al[23] that, although internal fixation significantly reduces grip strength in the initial stage of follow up, the aim should be early active and resistive goal-directed mobilization. Droll KP 2007[24] concluded that Stabilization with internal plate fixation following fracture of both bones of the forearm restores nearly normal anatomy and motion. Our results are comparable to other investigators reported in the literature.[25] there were some difficulties like illiteracy, surgical treatment phobia; poor socioeconomic conditions and irregular follow up while conducting the study.

CONCLUSION

The use of AO 3.5 mm small fragment dynamic compression plates for displaced diaphyseal fractures of the Forearm in adults is a very successful method of obtaining union and restoring optimum functional use of the extremity.

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Footnotes

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