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Results of Open Reduction and Internal Fixation of Proximal Third Both Bones of Forearm Fractures in Adults

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ABSTRACT
Background: For displaced proximal fractures of the forearm in the adult, open reduction and internal fixation with plating is usually considered as the best therapeutic option.
Objective: Improving functional outcome of patients with proximal third both bones forearm fracture in adults.
Patients and Methods: At Orthopedic Department of Zagazig University Hospital 12 patients with proximal third both bones of forearm fractures in adults were studied in prospective research. Open reduction and internal fixation through dynamic compression plate were done to all patients.
Results: the average operation time among the studied group were (59.8±6.8) minutes ranged from 30 to 95 minutes. Only one case, which had infection, had delayed union (19 weeks), which was treated by antibiotics, otherwise the average union time for all cases was (13.7±2.5) weeks and there was no un-union. Most of the studied group (66.7%) had excellent Mayo elbow performance index followed by (16.7%) had good score then fair and poor (8.3%) for each. There was statistically significant higher AO classification among poor and fair outcome than excellent and good outcome as (100.0%) of poor and fair outcome were A2.
Conclusion: Open reduction and internal fixation (ORIF) is appropriate treatment of both bones forearm fracture. Plate fixation was safe and effective treatment option for proximal both bones forearm fracture because it provided good function outcomes.
Keywords: Forearm Fractures, Internal Fixation, Open Reduction.

INTRODUCTION

Adults commonly sustain upper extremity injuries such as concordant radius and ulna fractures (also known as both bones forearm fractures). Direct or indirect stresses acting on the radius and ulna can cause these injuries. Indirect forces, such as axial loads during falls onto an outstretched hand, can produce fractures at different levels, but they are more likely to cause fractures at the same level in both bones. This type of fracture is difficult to stabilize in adults because of the large force required for fractured both bones[(1)].

Bony union and satisfactory functional outcomes can only be achieved in adult forearm fractures when the anatomy is restored correctly. Because of this, most adult forearm fractures necessitate surgery [(2)]. Both bones of the forearm fractures exhibit unique issues in addition to those found in all long-bone fractures, and conservative treatment of these fractures results in a poor functional outcome because of their anatomical qualities. A small amount of shortening and rotational misalignment occurs in other long bones, but the outcome is not significantly harmed. The forearm, on the other hand, is an exception. Regaining length, apposition, and axial alignment, as well as normal rotational alignment and the radial bow is essential for restoring appropriate range of supination and pronation of the forearm [(3)].

For displaced proximal fractures of the forearm in the adult, open reduction and internal fixation with plating is the preferred treatment approach. Compression has long been recognized as a useful technique for achieving rigid internal fixation. It has been discovered that compression treatments have a decreased non-union rate and reduce joint stiffness during rehabilitation [(4)].

It was the goal of this study; improving functional outcome of patients with proximal third both bones forearm fracture in adults in Zagazig University Hospitals.

PATIENTS AND METHODS

At Orthopedic Departments of Zagazig University Hospital, 12 patients with proximal third both bones of forearm fractures in adults were studied in prospective research, open reduction and internal fixation through dynamic compression plate were done to all patients.

Ethical consent:

Research Ethics Council at Zagazig University approved the study (ZU-IRB #9070) as long as all participants provided informed consent forms. Ethics guidelines for human experimentation were adhered to by the World Medical Association's Helsinki Declaration.

Inclusion criteria: Gender: both male and female, closed fracture in upper third of forearm, displaced fractures, and compound fractures (Gustilo classification type I).

Exclusion criteria: Pathological fractures, associated neurovascular injuries, presence of infection, compound fractures (Gustilo classification type II -III), and as a result of other injuries such as distal radioulnar joint (DRUJ) disruption and distal fracture of the forearm.

All Patients were subjected to:
1. A thorough review of the patient's medical history and an orthopedic examination.
2. X-ray anteroposterior and lateral views on affected side, elbow and wrist X-ray.

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3. All patients had full preoperative lab investigation before surgery including: Complete blood picture, Random blood sugar, Viral screen, Coagulation studies (PT/PTT) as well as Kidney and liver function tests.
4. Surgical technique:

Positioning:

With the patient lying on his back, a manual tourniquet was placed to the arm, the entire forearm was prepped and draped to isolate it in a sterile method, and the arm was supine on the table with an armboard, supination.

Antibiotic and tourniquet:

Before using a tourniquet, a single intravenous dosage of an antibiotic was delivered for infection prevention (Fig. 1).

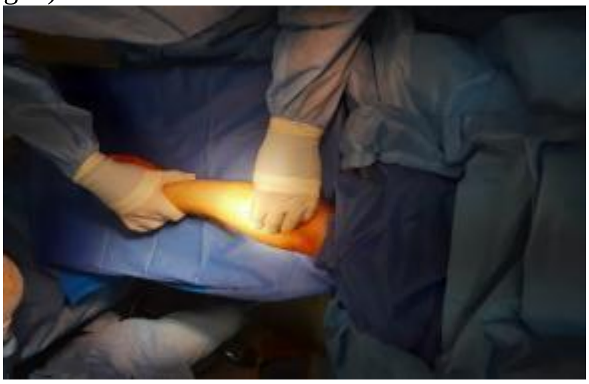

Fig. (1): A forearm completely prepared and draped with tourniquet applied on the operating table Approach to Radius (Henry).

Surgical Technique of radius: (Volar Approach to Radius (Henry):

Skin Incision: Over the fracture site, an incision was created about 10-15 cm long, beginning just outside of the elbow's biceps tendon and ending at the radial styloid process.

Superficial dissection:

A plane was developed between the muscles of the brachioradialis and the pronator teres after skin was transection; the transverse veins of the transversely running superficial veins were then ligated or transected. The proximal superficial radial nerve was then identified beneath the brachioradialis, and the radial artery branches were ligated to help the brachioradialis retract laterally.

Deep dissection of proximal third:

Dissection of the forearm is an exercise in preserving the posterior interosseous nerve as it passes through the body of supinator. The forearm was supinated completely to move the body of supinator, and therefore the nerve was kept away from the operative field. The biceps tendon down was followed to its lateral border, where a small bursa was encountered, then incised, to reveal the proximal radius. The medial edge of supinator was identified, and was elevated in a subperiosteal fashion from its insertion (Fig. 2).

Fig. (2): Longitudinal incision begins just lateral to biceps tendon on flexor crease of elbow over the fracture site of the proximal third of radius, Volar Approach to Radius (Henry).

Open reduction (Fig. 3 and 4):

Each end of the fracture was delivered into the wound in turn and cleared of clot and bone fragments. The periosteum was stripped back by only a millimetre or two to expose the fractured ends. Reduction was achieved by grasping each side of the fracture with bone holding clamps, exaggerating the fracture deformity by gently bringing the ends up into the wound, confirming rotational reduction, and then allowing the posterior cortices to come together. The fracture was reduced as the bone ends were allowed to relax back alignment. It was ensured that the lateral bow of the radius was restored.

Fig. (3): Reduction is achieved by grasping each side of the fracture with bone holding clamps.

Fig. (4): Drilling a hole through both cortices.

Internal fixation:

The fracture was most commonly transverse, the anterior (volar) surface of the radius was, helpfully, flat and a 3.5-mm dynamic compression plate was pre-contoured and used to achieve compression. Take note that the radius was bowed and the dynamic compression plate was straight. Therefore, each end of the plate sat towards the radial side, while the middle of the plate sat towards the ulnar side (Fig. 5).

It was possible to locate fractures using the soft tissue guidance. Using a depth gauge and a 2.7 mm drill bit, the proper 3.5 mm screw length was established. One screw each proximal and distal to the fracture was used in conjunction with a small-fragment compression plate that was at least three bicortical screws.

Closure: Drain 12 was placed after the fascia of the forearm was closed but before the subcutaneous tissue and skin were closed (Fig. 6).

Fig. (5): Plate fixation by 3.5 mm cortical screws.

Fig. (6): Subcutaneous tissue closure.

Surgical Technique of ulna: (subcutaneous ulnar approach)

Skin Incision: After determining the location of the fracture, an incision of 15 centimetres in length and centered over it was made along the subcutaneous border of this bone (Fig. 7).

Dissection: Between the extensor carpi ulnaris (radial nerve) and the flexor carpi ulnaris (flexor muscles of the elbow), the bone was revealed beneath the skin in this location (ulnar nerve). To find the fracture, a cut into the flexor and extensor compartments of the forearm was done.

Open reduction (Fig. 8):

Bone-holdings on both ends of the bone pieces was placed to keep them in place and reduce the ulna fracture site after removing hematoma and intervening tissue from the fracture site with curettes and irrigation. Exaggerating the fracture deformity was done by pulling the ends up into the wound, confirming rotational reduction, and then allowing the posterior cortices to join together, traction was used to bring fracture fragments together. By allowing the fractured ends of the bones to rest and realign, the risk of further damage was reduced.

Fig. (7): Open reduction by grasping each side of the fracture with bone-holding clamps.

Fig. (8): Dynamic compression plate fixation of ulna on posteromedial surface.

Internal fixation: The fracture was most commonly transverse. The bone was roughly triangular in cross-section and the pre-bent compression plate was placed on the most convenient surface. The posteromedial surface of the ulna was covered with a plate to treat ulna fractures.

Irrigation and Hemostasis: The tourniquet was removed and carefully any bleeders was cauterized, keeping an eye out for any injury to the radial artery or veins.

Closure: Closure of the forearm fascia as well as of the subcutaneous tissue and skin was accomplished as per usual procedure

Dressing and Splint:
Slings and a slab were applied for immobilization follow the incision dressing (gauze and betadine).

Postoperative regime:
All patients were requested to execute active finger movements while they were immobilized with an above-elbow slab. Appropriate antibiotics and analgesics were given. All patients were followed every two weeks in first month. The stitches of all patients were removed after two weeks. Plain X-ray was done immediately after operation, six weeks and three months. Once firm radiographic healing occurred, all patients were allowed to utilize the afflicted limb without weight bearing and prescribed physiotherapy for range of motion and strengthening activities. Upon follow-up, patients were evaluated for pain, active and passive range of motion, daily activities, power, infection and other complications. The patients were estimated by Mayo elbow performance index and manual doing of supination and pronation.

Statistical analysis
In order to analyze the data acquired, Statistical Package for the Social Sciences version 20 was used to execute it on a computer (SPSS). The quantitative data were presented in the form of the mean, median, standard deviation, and range. The information was presented using qualitative statistics such as frequency and percentage. Pearson Chi-Square or Fisher's exact test was used to compare qualitatively independent data. The significance of a P value of 0.05 or less was determined.

RESULTS
The demographic characteristics of the studied patients are shown in table 1.

Table (1): Demographics of the studied patients

Demographic data	The studied group	
	No=(12)	%
Age (years) Mean ± SD Median (Range)	39.8±6.8 42.5 (16-65)	
Age (years)		
16-30 years	5	41.7%
30-45 years	5	41.7%
45-65 years	2	16.6%
Sex		
Male	8	66.7%
Female	4	33.3%

The average operation time among the studied group was 59.8±6.8 **(Table 2).**

Table (2): The operation time among the studied group

The operation time (minutes)	The studied group	
	No=(12)	%
Mean ± SD Median (Range)	59.8±6.8 63.5 (30-95)	

Only one case who had infection had delayed union (19 weeks), which was treated by antibiotics, otherwise the average union time for all cases was (13.7±2.5) weeks **(Table 3).**

Table (3): The union time and union rate among the studied group

The union data	The studied group	
	No=(12)	%
The union time (weeks) Mean ± SD Median (Range)	13.7±2.5 12.5 (10-19)	
The union rate		
Union	12	100.0%
Un-union	0.0	0.0%

Most of the studied group didn't have any postoperative complications **(Table 4).**

Table (4): Postoperative complications among the studied group

Postoperative complications	The studied group	
	No=(12)	**%**
Superficial infection	**1**	**8.3%**
No	**11**	**91.7 %**

Post follow up range of motion (ROM) is shown in table **(Table 5)**.

Table (5): Post follow up ROM among the studied group

Post Follow up ROM	The studied group	
	No=(12)	%
Supination (degree) Mean ± SD Median (Range)	76.9±2.5 75.8 (65-85)	
Pronation (degree) Mean ± SD Median (Range)	83.5±2.5 80.8 (62-90)	
Elbow joint ROM	The studied group	
	No=(12)	%
Flexion (degree) Mean ± SD Median (Range)	143.15±1.5 139.5 (130-145)	
Extension (degree) Mean ± SD Median (Range)	0.65±1.4 0.59 (0.0-5)	
Wrist joint ROM	The studied group	
	No=(12)	%
Dorsiflexion (degree) Mean ± SD Median (Range)	75.7±1.9 73.8 (70-85)	
Volar flexion (degree) Mean ± SD Median (Range)	73.06±0.87 70.05 (72-81)	

There was statistically significant older age among poor and fair outcome than excellent and good outcome **(Table 6).**

Table (6): Relation between Mayo elbow performance index and demographic characteristics of the studied group

Demographic data	Mayo elbow performance index				P
	Excellent and Good (N=10)		Fair and Poor (N=2)		
	No.	%	No.	%	
Age (years)					
16-30 years	5	50.0%	0	0.0%	**0.03**
30-45 years	4	40.0%	1	50.0%	
45-65 years	1	10.0%	1	50.0%	
Sex					
Male	7	70.0%	1	50.0%	0.9
Female	3	30.0%	1	50.0%	

There was statistically significant higher AO classification among poor and fair outcome than excellent and good outcome as (100.0%) of poor and fair outcome were A2 **(Table 7).**

Table (7): Relation between Mayo elbow performance index, AO classification and post-operative complications among the studied group.

AO classification	Mayo elbow performance index				P
	Excellent and Good (N=10)		Fair and Poor (N=2)		
	No.	%	No.	%	
AO classification					
A3.1	6	60.0%	0	0.0%	**0.02**
A3.2	4	40.0%	2	100.0%	
Postoperative complications					
Superficial infection	0.0	0.0%	1	50.0%	0.6
No	10	100.0	1	50.0%	

A: X-ray prior to operation. **B:** Intraoperative X-ray.

C: Follow up x-ray after 28 weeks. **D:** Clinical follow up after 28 weeks.

Fig. (9): Male patient, 53 years old. Co-morbidities: No. Etiology of fracture: Fall from Height (FFH). Fracture side: left. AO classification: A 3.2. Closed fracture of proximal both bones of forearm. Fracture of both bones forearm was fixed by double plates (DCP 3.5 plate).

DISCUSSION

The fracture of the forearm is a rather typical occurrence in trauma and emergency departments, particularly in children under the age of 18. Injuries like this can be caused by both direct and indirect trauma. Pain and swelling are among the first signs that emerge from a traumatic injury, as well as local soreness and apparent deformities at the injury site. Surgery to correct forearm fractures, either closed reduction and internal fixation or open reduction and internal fixation, is the most common treatment [(2)].

The present study showed that the average operation time among the studied group was (59.8±6.8) minutes ranged from 30 to 95 minutes. The average follow up period among the studied group was (19.8±6.8) weeks ranged from 12 to 24 weeks. The average amount of intraoperative bleeding among the studied group was (80.9±20.5) ml ranged from 35 to 250 ml.

This study showed only one case who had infection had delayed union (19 weeks), which was treated by antibiotics, otherwise the average union time for all cases was (13.7±2.5) weeks and there was no un-union. **Ali *et al.*[(5)] and Parajuli *et al.*[(6)]** found that the recorded mean union time in all patients was about 10.87±3.04 weeks. This difference in results could be explained by age variation among all patients. On comparing time to union with age of patients, younger patients had more rapid union time.

Regarding to complication of the studied group, (91.7%) didn't have any postoperative complications and (8.3 %) of them had superficial infection. **Matejcic *et al.*[(7)]** reported that wound infection and pseudoarthrosis are the two most common side effects. Reosteosynthesis with spongioplasty was used to treat pseudoarthrosis in 3.9 percent of the patients. In 2.8 percent of instances, osteitis was found, which was treated with antibacterial therapy in conjunction with surgical intervention.

The overall complications rate was 27.8%. Angulation was recorded in 2 patients (11.1%), disease was recorded in 2 patients (11.1%), and mal-rotation was recorded in only one patient (5.6%). The studies conducted by **Ali *et al.*[(5)] and Parajuli *et al.*[(6)]** faced complications such as superficial diseases and prominence.

There was statistically significant higher AO classification among poor and fair outcome than excellent and good outcome as (100.0%) of poor and fair outcome were A2. Regarding postoperative complications, there was no statistically significant difference.

Our study showed the supination and pronation angles, and the flexion and extension angles had less limited restriction of movement compared to study done by **Kapoor *et al.*[(8)]**. 9 out of 50 patients had a restricted range of motion in the forearm, according to that study. **Kapila *et al.*[(9)]** found that at least four (8 percent) individuals had lost the ability to move their forearms in a supinated or pronated position (losing motion of 15-30 degrees).

In 2010 **Kloen *et al.* [(10)]** identified 29 (62 percent) great outcomes, 8 (17 percent) satisfactory, and 10 (21 percent) unsatisfactory results.

Kapila *et al.*[(9)] documented that mean time for radiological bony union was 9.2 weeks (Range=6-13 weeks). **Sahu *et al.*[(11)]** found that all the fractures united at an average 10-12 weeks without any malunion.

Kloen *et al.* [(10)] revealed that forearm fractures were treated intramedullary in twenty people during a three-year period. Forearm fractures treated with closed reduction and immobilisation in plaster had satisfactory outcomes in the majority of patients. A sort of internal fixation would be necessary if a sufficient reduction could not be achieved or maintained using conservative techniques or if they failed. ORIF had a very important solution to this problem. The average time to bone union for all patients was 5.8 weeks, with all patients achieving full bone union in an excellent condition.

One of the benefits of plate-and-screw fixation is the ability to reduce the fracture under direct visual inspection while simultaneously compressing it. If necessary, a bone graft can be performed. Because the fixation is firm, a cast is not required for postoperative immobilization [12].

Compression plates and screws have been shown to be effective in the treatment of forearm shaft fractures, according to the AO-group. Once employed as a treatment for forearm bone fractures, it has since become a common practice[13,14].

One significant drawback is the possibility of refracture following removal of the compression plate, necessitating six weeks of splinting and six months of restraint on the forearm [15].

CONCLUSION

It could be concluded that good clinical results with minimal complications could be achieved in the treatment of proximal both-bone forearm fractures in cases using ORIF. Despite minimal angulation, good functional outcome, cosmetically acceptable appearance could be obtained because of rapid healing, remodeling of angulations in patients.

Our study suggests that ORIF is appropriate treatment of both bones forearm fracture. Plate fixation was safe and effective treatment option for proximal both bones forearm fracture because it provided good function outcomes, ORIF should be taken as a priority for both bones forearm fracture.

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