

**FUNCTIONAL RESULTS OF SURGICAL TREATMENT OF UNUNITED DIAPHYSEAL FOREARM WITH COMPRESSION PLATE FIXATION AND AUTOGENOUS BONEGRAFTING**

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**ABSTRACT**

**Introduction:** The treatment of forearm fracture-nonunions continues to represent a therapeutic challenge, and reported outcomes are moderate at best. Limiting aspects of this particular anatomic location include the relation between restoration of shaft length with the anatomy and long-term functional outcome of adjacent joints, as well as the risk of elbow and wrist stiffness related to prolonged immobilization. The present study was designed to assess the outcome of autologous bone grafting with compression plating and early functional rehabilitation in patients with forearm fracture non-unions. **Methods:** Prospective follow-up study in 23 consecutive patients presenting with non-unions of the forearm diaphysis (radius,  $n = 8$ ; ulna,  $n = 9$ ; both bones,  $n = 7$ ). Surgical revision was performed by restoring anatomic forearm length by autologous bone grafting of the resected non-union from the iliac crest and compression plating using a 3.5 mm dynamic compression plate (DCP) or limited-contact DCP (LC-DCP). The main outcome parameters consisted of radiographic bony union and functional outcome, as determined by the criteria defined by Grace and Everssman 1980. Patients were routinely followed on a short term between 2 weeks to 9 months. **Results:** Radiographically, a bony union was achieved in 22/23 patients within a mean time of 5 months of revision surgery (range 3 to 7 months). Clinically, 13/23 patients showed an excellent functional outcome, 8/23 patients showed a good functional outcome, 2/23 patients showed a bad functional outcome according to the Grace and Everssman criteria. No patient had a postoperative infections. Two case of postoperative failure of fixation was seen, one of them developed to malunion and the second one stay as a nonunion case. **Conclusion:** Revision osteosynthesis of forearm nonunions by autologous iliac crest bone grafting and compression plating represents a safe and efficacious modality for the treatment of these challenging conditions.

**KEYWORDS:** Forearm, Compression plate, nonunion, bonegrafting.**INTRODUCTION**

Non unions are a major complication of diaphyseal fractures of the forearm, with eventual variable dysfunction of the upper limb and hand. Non union is defined as absence of radiological and clinical signs of unions after an average period of six months. The use of dynamic compression plate has totally changed the prognosis of surgical treatment of diaphyseal fractures of the radius and ulna.

Although large series in the literature have shown that this technique is simple with a low complication rate<sup>[1,2]</sup>, the incidence of aseptic nonunion of the forearm fractures remains significant between 2% and 4% in various publications.<sup>[1,3-7]</sup>

The management of these non unions remains difficult due to the poor bone mass, the existence of previous

implant material and joint stiffness that is associated with long-term immobilization.<sup>[8]</sup> The goal of surgery is to achieve complete union of the fractures and restore the functional anatomy between the radius and the ulna, so as to obtain a normal hand function.<sup>[9]</sup> This surgical stabilization at the nonunion should be associated with the compression of the fracture site and stimulation of bone formation by bone grafting and or decortication.

In this single-centered prospective study, we aim to analyze the causative factors of aseptic non union of the forearm fractures and evaluate the clinical and radiological results and the operative treatment with a dynamic compression plate, bone grafting and decortication.

## METHODS

A prospective analysis of database of all consecutive patients treated between (2021-2023) for fracture-nonunions of the forearm was performed at a single academic center (Dept. of Orthopaedics and Traumatology, Tishreen University of Lattakia, Syria). The inclusion criteria consisted of all adult patients (> 18 years) of either gender with posttraumatic nonunions of the radius and/or ulna shaft, in absence of an active infection. Patients with nontraumatic forearm pseudarthrosis, Galiazy and Monteggia fracture dislocations, infected nonunions, or with an associated neurological impairment of the ipsilateral upper extremity, which may preclude from an adequate functional assessment, were excluded from analysis.

The pre-operative plan included plain X-rays of the forearm, wrist and elbow, in antero-posterior (a.p.) and lateral views. The presence of infection was excluded by preoperative analysis of systemic infection parameters (WBC, ESR, CRP) and by intraoperative tissue samples of the resected nonunions which were sent for microbiology cultures and histopathological workup. The standardized treatment concept consisted of resection of the forearm nonunion, autologous bone grafting with a tricortical graft from the iliac crest with anatomic restoration of the forerarm length, as determined by intraoperative fluoroscopy assessment of the adjacent joints, and compression plating using a stainless steel small fragment (3.5 mm) dynamic compression plate (DCP) or limited-contact DCP (LC-DCP). Radiological and functional outcome was determined at a 9 months follow-up, with standardized intervals at 2 weeks and 3, 6, 9 months after revision surgery. The functional outcome was evaluated according to the criteria defined by Grace and Everssman.<sup>[14]</sup> These criteria include the range of motion of forearm pro-/supination, wrist and elbow flexion and extension. Bony union was defined in plain X-rays of the forearm in a.p. and lateral views, in absence of pain at the nonunion site.

## RESULTS AND DISCUSSION

23 patients (17 males and 6 females; median age 42 years, with extremes of 25 and 55) presenting with forearm fracture-nonunions were prospectively enrolled into this study. Of these, 14 patients had their dominant arm affected. 6 patients presented with a both bone fracture-nonunion, and 17 patients had a single bone affected (8 radius, 9 ulna shaft). Patients presented with a fracture- nonunion within 6 to 12 months after the initial surgery (median of 9 months). Radiographically, a bony union was achieved in 22/23 patients within a mean time of 5 months of revision surgery (range 3 to 7 months). Clinically, 21/23 patients showed a good functional outcome, according to the Grace and Everssman criteria. The nonunion sites: 14 fractures in the middle third, 7 in

the distal third, and 8 fractures in the proximal third. In 12 cases, the initial treatment of the fracture consisted of intramedullary pinning on by Kirschner wire or Elastic nail, 4 plate and screws in one bone and intramedullary pinning in the other bone, 1 plate and screws, and 6 Conservative treatment.

### Before surgery

- Average elbow range of motion was 112.8 degrees  
The patients' measurements ranged between (70 and 135) degrees.

- Average movement of the numerator is determined by 15 degrees.

- The average forearm pronation motion was 49.1 degrees.

The patients' measurements ranged between (25 and 65) degrees.

- Average forearm supination motion was 54.1 degrees.

The patients' measurements ranged between (40 and 65) degrees.

- Average wrist flexion movement was 48.2 degrees.

The patients' measurements ranged between (20 and 70) degrees.

- Average wrist extension motion was 55.2 degrees.

The patients' measurements ranged between (30 and 75) degrees.

### Nine months after surgery

- Average elbow flexion movement was 125.8 degrees

The patients' measurements ranged between (85 and 145) degrees.

- Average The numerator is about five degrees.

- The average forearm pronation motion was 60.6 degrees.

The patients' measurements ranged between (40 and 80) degrees.

- Average forearm supination motion was 63.2 degrees.

The patients' measurements ranged between (45 and 75) degrees.

- Average wrist flexion movement was 59.3 degrees.

The patients' measurements ranged between (40 and 75) degrees.

- Average wrist extension motion was 62.1 degrees.

Where the patients' measurements ranged between (35 and 75) degree.

The rangeor motion	wrist flexion	wrist extension	forearm pronation	forearm supination	elbow flexion	
Resultsbefore Surgery	48.2	55.2	49.1	54.1	112.8	15
Results after Surgery	59.3	62.1	60.6	63.2	125.8	5

**Evaluate results by index: Grace and Everssman 1980**

results	Excellent	Acceptable	Bad
the patients	13	8	2
The ratio	56.5%	34.8%	8.7%

**The relationship between the results of the indicator Grace & Everssman and Patient gender**

P=0.02	Males	Females
Excellent (13)	10 (58.8%)	3 (50%)
Acceptable (8)	6 (35.3%)	2 (33.3%)
Bad (2)	1 (5.9%)	1 (16.7%)

**The relationship between the results of the indicator Grace & Everssman and the Age of the patient:**

P=0.03	(25 – 34)	(35 – 45)	(46 – 55)
Excellent (13)	5 (83.3%)	6 (75%)	2 (%22.2)
Acceptable (8)	1 (16.7%)	2 (25%)	5 (55.6%)
Bad (2)	0 (%0)	0 (%0)	2 (%22.2)

**The relationship between the results of the indicator Grace & Everssman And the place of nonunion:**

P=0.1	9 ulna	8 radius	6 both bone
Excellent (13)	5 (55.6%)	6 (75%)	2 (33.3%)
Acceptable (8)	3 (33.3%)	2 (25%)	3 (%50)
Bad (2)	1 (%11.1)	0 (%0)	1 (%16.7)

**Complications**

Complications	the patients	The ratio
vascular or nerve injury	0	0%
Refractory materials	0	0%
Loosen materials	2	8.7%
Cross coalescence	0	0%
Non-healing	1	4.3%
Malunion	1	4.3%
sympathetic atrophy reflection	5	21.7%
Chambers syndrome	0	0%
ectopic muscleossification	0	0%
Chronic pain at the surgical site	2	8.7%
Chronic pain at the siteof the graft	4	17.4%
Infection at the surgical site	0	0%
Infection at the site of the graft	1	4.3%
Poor wound healing	1	4.3%

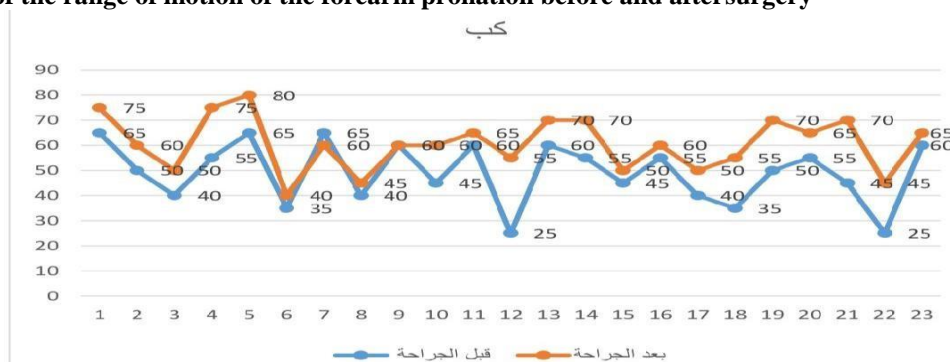
- The percentage of males was greater than that of females, as most of the infections were of active age. Physical and production are in males, and this is related to their profession, work, and physical activity, which differs from females in our society.
- The predominant age group is the youth group (25-55) Physical activity and workgroup.
- A mean radiographic fusion occurred within 5 months (range 3-7 months) in all patients except one case (95.6%).
- Excellent functional outcomes were higher when the injury was in the isolated radius (75%) followed by the ulna (55.6%), while acceptable and poor functional outcomes were higher when the injury was in both bones.
- The primary cause of fracture in two-thirds of cases was a result of high-energy injuries such as falls from a height and accidents, which led to fragmentation and major damage to the bone, compared to simple fractures that occurred in low-energy injuries.
- The initial fracture treatment in most cases of nonunion was conservative treatment with plaster or surgical treatment with rods, which indicates the inadequacy of this type of treatment in achieving the healing of closed fractures of the forearm bone in adults, unlike pressure plates, which achieved good results in treating these fractures
- Excellent and acceptable functional outcomes were higher in males than in females, while poor outcomes were higher in females. Excellent functional outcomes were higher in the first and second age groups, while acceptable and poor outcomes were higher in the third age group, with a statistically significant relationship. This is due to the fact that most of the patients in our study were males, and most of the males were from the younger age

groups, while most of the females were from the older age groups. This explains the variation in functional outcomes, as advancing age has an effect on the speed of healing and the speed of response to physical therapy, in addition to the presence of a deficiency in bone density and the prevalence of accompanying diseases, and what these reasons and factors may have of an effect on the functional outcomes of patients.

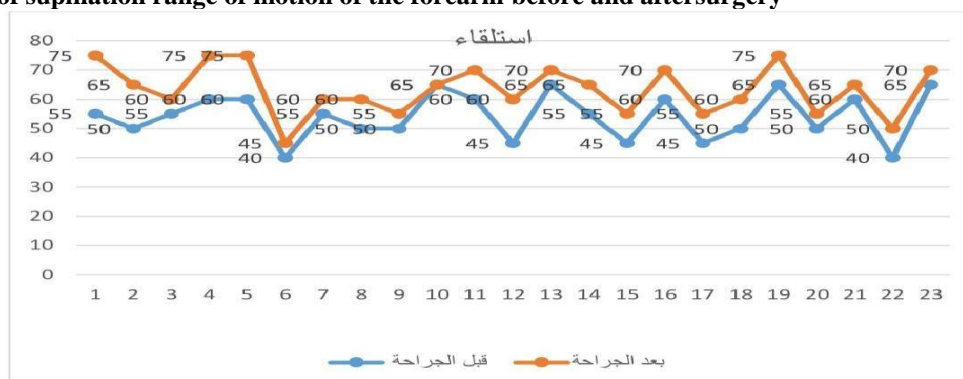
- Complications occurred in several patients, with each patient having more than one complication.
- Reflex sympathetic dystrophy was the most common complication (5 cases) at a rate of (21.7%), two of which were due to loosening of the locating materials and three cases were due to insufficient adherence to physical therapy and rehabilitation at the beginning.

- There were two cases in which there was a loosening of the implant materials (8.7%) as a result of a forearm injury during the rehabilitation period. One of them developed into a defective fusion in both bones, and the other one remained non-union in the ulna bone without healing, and they had chronic pain at the surgical site.
- There were also four cases of chronic pain at the site of the graft, at a rate of (17.4%).
- No infection occurred in any of the cases at the surgical site.
- Only one case had a superficial infection with *Staphylococcus aureus* at the graft site, which was treated with bandages and antibiotics for several days until complete recovery occurred.

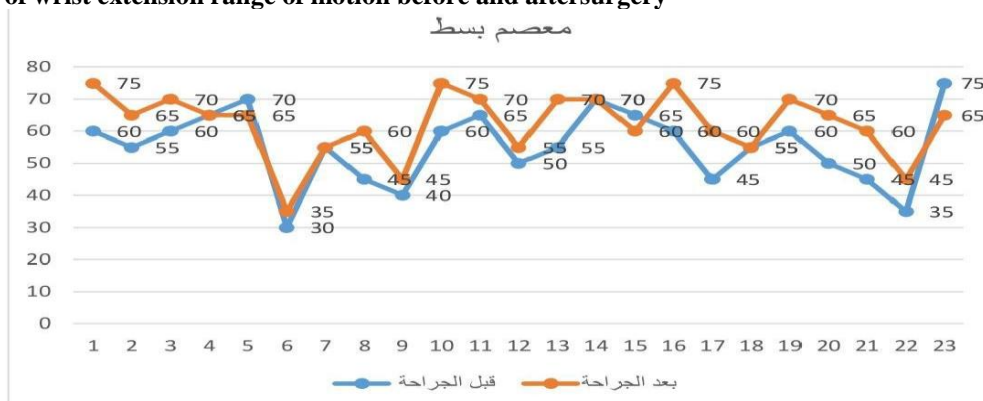
#### Comparison of the range of motion of the forearm pronation before and after surgery



#### Comparison of supination range of motion of the forearm before and after surgery



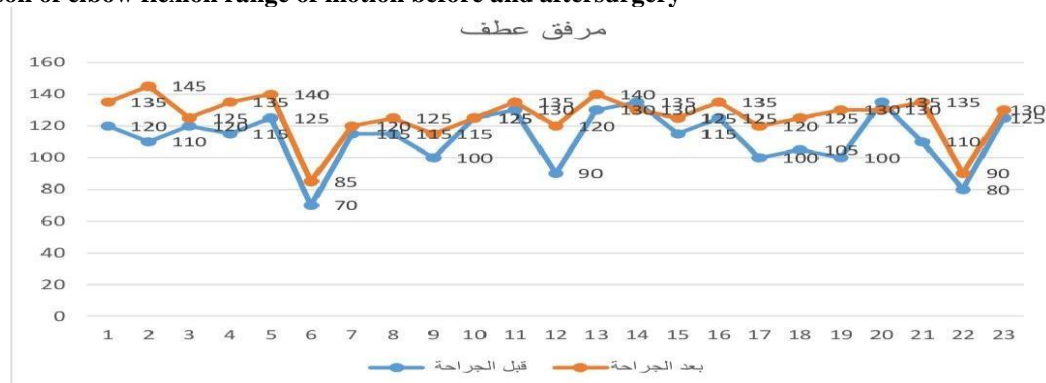
#### Comparison of wrist extension range of motion before and after surgery



### Comparison of wrist flexion range of motion before and aftersurgery



### Comparison of elbow flexion range of motion before and aftersurgery



### CONCLUSION

1. The use of plates and screws with autografting from the iliac bone is considered an ideal method for treating forearm nonunion.
2. The patient must adhere to physical and rehabilitation therapy after surgery to obtain the best functional results.

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