Al-Azhar University Journal
for Virus Research and Studies

Surgical Treatment of Non-United Ulnar Fracture

Mohamed Abd El-Aziz Mohamed[1], Ibrahim Ahmed Hussein[1] and Emad Mohamed Abdou Zaye [3]

[1]Department of Orthopedic Surgery, Faculty of Medicine for Girls, Al-Azhar University.

***E-mail: Mohammed_ab_1@yahoo.com**

Abstract

Aseptic nonunion of the ulna is a major complication of forearm fractures, accounting for 2% to 10% of all forearm fractures. Our study aims to evaluate the functional and radiological results of surgical treatment of diaphyseal aseptic nonunion of the ulna, with autologous bone grafting and internal plate fixation. A series of 20 patients were prospectively reviewed, the average age was 35 years with a mean of 36,60 years (range 20-63 years). Anderson's score was used to evaluate our results. Fifteen had very excellent results, four good and one poor. Consolidation of the no united ulnar fracture was attained in 6.2 months. Therefore, the functional prognosis of the upper limb imposes the need for adequate treatment. This management strategy has enabled us to have satisfactory results. However, the best treatment for nonunion remains the preventive treatment with optimal management and care of the forearm fractures.

Keywords: Ulna, Diaphyseal fracture, Nonunion.

1. Introduction

Non-unions are a major complication of diaphyseal fractures of the forearm, with eventual variable dysfunction of the upper limb and hand [1]. Nonunion is defined as the absence of radiological and clinical signs of unions after an average period of six months. The use of a dynamic compression plate has changed the prognosis of surgical treatment of diaphyseal fractures of the ulna. Although large series in the literature have shown that this technique is simple with a low complication rate [1, 2], the incidence of aseptic nonunion of the forearm fractures remains significant between 2% and 10% in various publications [1, 3, 4]. The management of these nonunion remains difficult due to the poor bone mass, the existence of previous implant material and joint stiffness that is associated with long-term immobilization [5]. 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 [6]. 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 according to Judet et al [7]. Other treatment options are discussed, such as bone-marrow injection, and induced membrane technique which are not the choice of our surgeons. In this single-

centred prospective study, we aim to analyze the causative factors of aseptic nonunion of the forearm fractures and evaluate the clinical and radiological results and the operative treatment with a dynamic compression plate, bone grafting and decortication.

2. Patients and Methods

This is a prospective study of 20 patients treated between May 2020 and May 2021 for aseptic diaphyseal nonunion of the ulna. The inclusion criteria were the existence of aseptic nonunion of the diaphysis of ulnar fracture treated with compression plate and screws and associated with an autogenous iliac bone graft and osteomuscular decortication. Exclusion criteria were septic nonunion, acute ulnar fractures and those treated with other therapeutic modalities. We applied the classification of AO when we used the initial radiographs to classify fractures of the forearm [8]. Comparing the radiographs of delayed unions and nonunion of the forearm fractures, we noticed the absence of bone consolidation in the first stage after a period going from three to six months of the initial treatment, whereas the radiographs of the second stage showed a total lack of union after six months. On these radiographs, we also analyzed the level of nonunion, and its type as well as the initial treatment of the fracture of the ulna. Furthermore, the interpretation of this imagery also helped us search for technical errors and factors which would have contributed to nonunion of these 20 patients, there were 14 men and 6 women; average age was 34.52 years, with extremes of 20 and 63, a standard deviation of 11.78 and a median of 36. Our center had initially taken care of six patients. We had 9 cases with fractures on the left side, and 11 cases on the right. Among our 20 patients, 12 patients had fractures on their dominant side. The nonunion sites: 9 fractures in the middle third, five in the distal third, and six fractures in the proximal third. In all cases, the initial treatment of the fracture consisted of open reduction and internal fixation by plate and screws. The time between initial treatment and the treatment of nonunion was seven months (range: 5 to 16 months). Thus, three of our patients were operated on for six months, which is theoretically considered as the period for diagnosis of nonunion. Conventionally, we differentiated between two types of nonunion: a viable nonunion (hypertrophic or oligotrophic) with a large callus or malunion that is mechanically incompetent, and an atrophic nonunion (or devitalized nonunion) without callus, which required an osteogenic treatment **(Fig 1)**. In our series, 60% of nonunion were oligotrophic (12 cases), 25% were hypertrophic (5 cases) and 15% were atrophic (3 cases).

2.1 Surgical technique

Based on the criteria of Corrales et al. [9], the operating indications relied on the existence of clinical signs of nonunion (pain and / or mobility of the fracture) and radiological signs (lack of bone consolidation) after six months since the start of treatment of the initial fracture. The incision used was the dorsal approach centered on the ulnar ridge for the ulna. The first surgical step consisted of removing the osteosynthesis implant applied previously, then the nonunion focal spot was cleared of the fibrosis tissue and the tissue-ingrowth associated with medullary recanalization. Besides, we obtained routine bacteriological samples and did an osteomuscular decortication. The graft was then taken from the anterior ipsilateral iliac crest and packed opposite the nonunion focal spot. Fixation with dynamic plate compression (type DCP (3.5mm)) was applied after manual compression of the nonunion focal spot. The optimum application included at least three screws on either side of the focal spot. The upper limb was immobilized in a splint for three weeks after the operation, Patient were

allowed to do passive and active exercise in a splint and antibiotic prophylaxis was instituted with first-generation cephalosporin for 48 hours. Postoperatively functional rehabilitation (passive and active) of the proximal and distal joints was carried out from the second day. All bacteriological samples taken were negative **(Fig 2)**. The final functional result was assessed by Anderson and colleagues [10]. This scoring system, which was recently used by Ring et al [11], was a united fracture with <10° loss of elbow or wrist motion and < 25% loss of forearm rotation as excellent, a healed fracture with <20° loss of elbow or wrist motion and < 50% loss of forearm rotation as satisfactory, a healed fracture with more than 30° loss of elbow or wrist motion and more than 50% loss of forearm rotation as unsatisfactory, and a malunion, non-union, or unresolved chronic osteomyelitis as failure Table 1. The post-operative radiological evaluation included AP and lateral views of the forearm. The consolidation was confirmed based on the existence of the two orthogonal evidence of bony bridges between the two ends of the nonunion focal spot, and absence of pain or tenderness at the fracture site. The radiological study was also to detect any evidence of malunion and to measure its angulation in the frontal and sagittal planes.

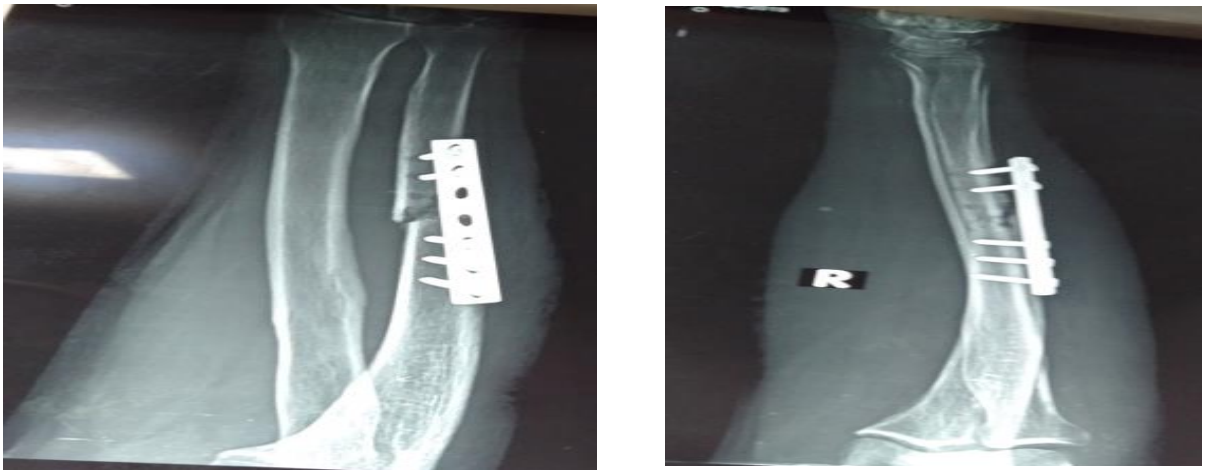

Figure 1: P. X-ray of non-united ulnar fracture fixed by DCP (AP and lateral views).

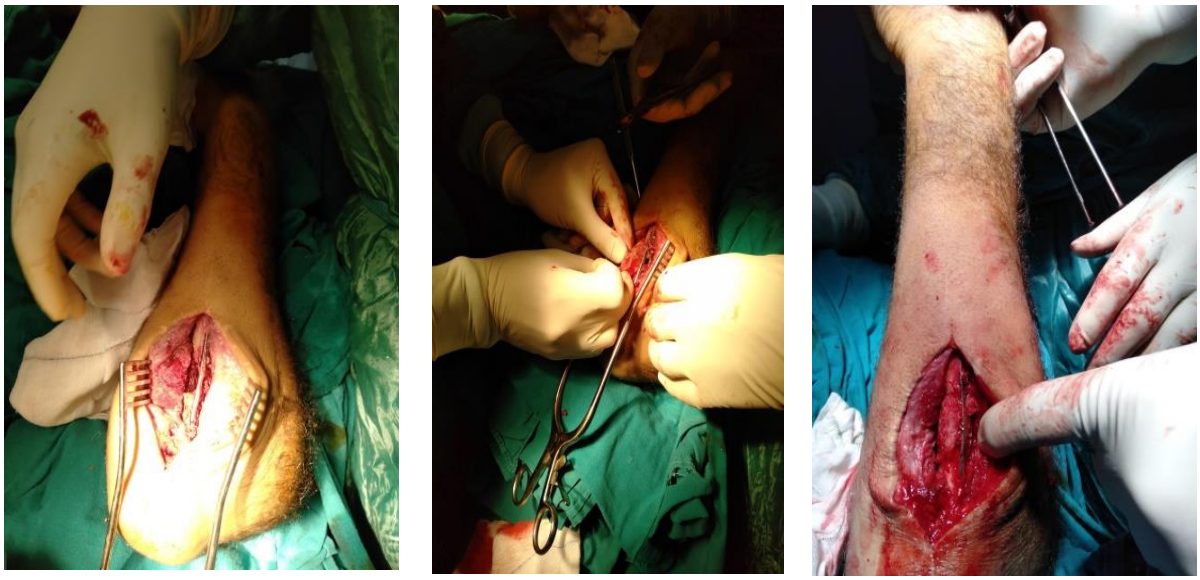

Figure 2: Intraoperative procedures of fixation of non-united ulnar fracture by LCP with iliac bone graft.

Table (1): Demographic & clinical characteristics among the two groups.

Result	Union	Elbow or Wrist Rom	Supination Pronation
Excellent	Present	<10°loss	<25°loss
Good	Present	<20°loss	<50°loss
Fair	Present	<30°loss	>50°loss
Poor	Nonunion with or without loss of motion		

3. Results

The results were evaluated according to the fracture union, functional results and complications. Twenty patients were followed up for 6 months, and functional assessment was done according to the Anderson score (10), to assess every patient at 6 months postoperatively. Fifteen patients had excellent results (75 %), four had good results (20 %) and one patient had poor results (5%). The excellent and good results were grouped as satisfactory (95 %), while the poor as unsatisfactory (5%) (Table 2) (Fig 3).

Table (2): Distribution of the studied cases according to functional outcome.

Outcome	No.	%
Excellent	15	75.0
Good	4	20.0
Poor	1	5.0

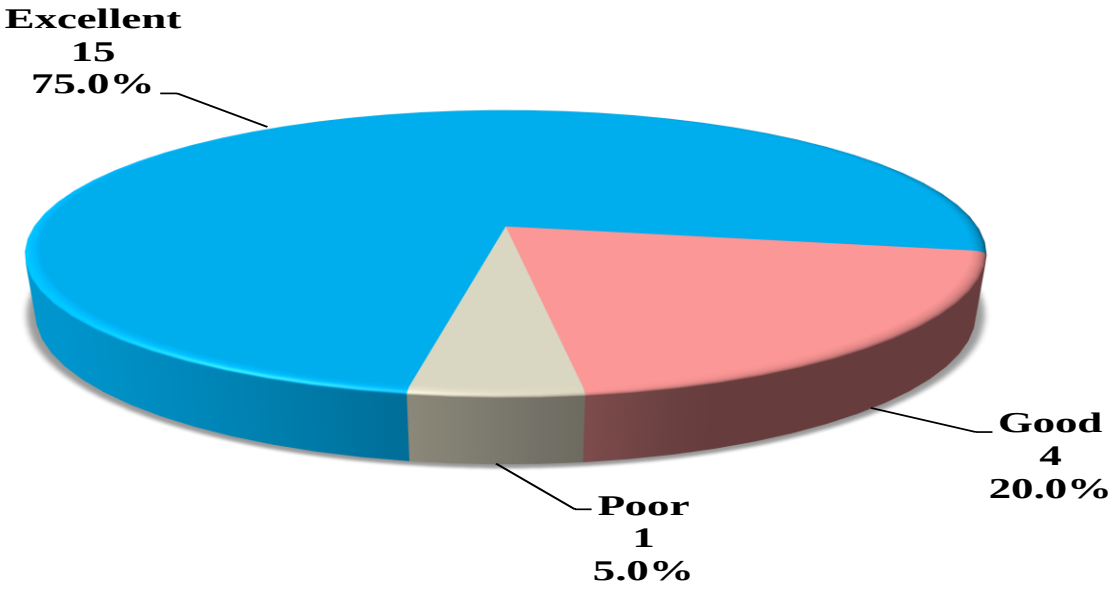

Figure 3: Distribution of the studied cases according to outcome.

3.1 Radiological Outcome

Union:

The time of radiological union of the fracture where bone trabeculae cross the fracture gap range between 3 to 5 months, fifteen cases (75%) achieved radiological union within 3 months, two patients (10%) within 4 months, two patients (10%) within five months and one case was reported as non-union (Table 3) (Fig 4).

Table (3): Distribution of the studied cases according to time of fracture union (n = 20).

Time of fracture union	No.	%
3 months	15	75
4 months	2	10
5 months	2	10
Nonunion	1	5

Figure 4: Postoperative revision AP and lateral views of united ulnar fracture fixed by LCP with iliac bone graft**.**

3.2 Functional outcome

Motion is one of the most important objective findings in the assessment of our results, at the last follow-up visit, the active range of motion was measured with a goniometer according to Andrson score [10] (Table 4), There was a progressive improvement of range of elbow, wrist and forearm rotation after 3 months of follow up. 15 cases (75%) with elbow flexion \ extension (140°\0°), wrist flexion \ extension (80°\70°) and supination\pronation (80°\80°) were excellent scores,4 cases (20%) with elbow flexion \ extension (120°\0°), wrist flexion\extension (60\60) and supination\pronation (70°\70°) were good score and One case (5%) didn't unite which was poor score.

Table (4): Distribution of the studied cases according to functional outcome.

No.	Elbow flexion\extension	Forearm Supination\pronation	Wrist flexion\extension	Score	%
15	140°\0°	80°\80°	80°\70°	Excellent	75
4	120°\0°	70°\70°	60°\60°	Good	20
1	didn't united			Poor	5

3.3 Complications

Overall, five complications happened in 5 cases (25%).

Non-union:

One case (5%) in our study was considered as nonunion. A 63-year-old diabetic, hypertensive, heavy smoking male patient with atrophic nonunion of proximal 1\3 ulnar fracture, revision surgery was done by ORIF with LCP and iliac bone graft and didn't appear union until the sixth month **(Fig 5)**.

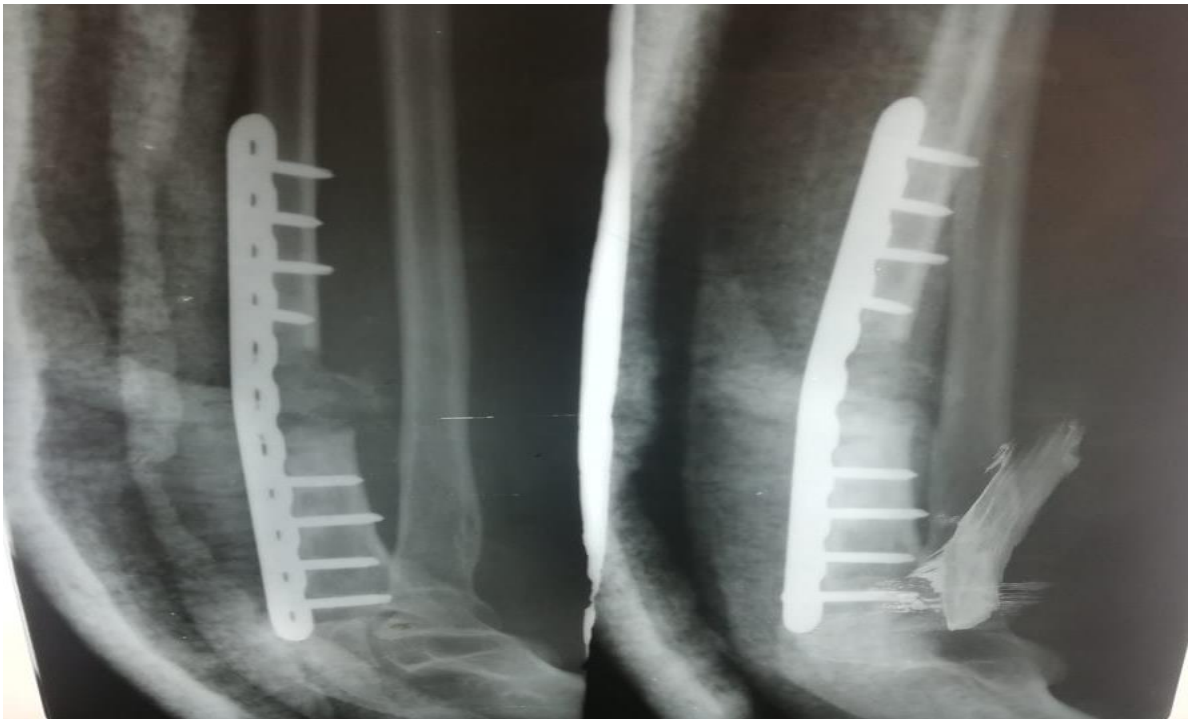

Figure 5: 6-month Postoperative AP and lateral views of revision of non-united ulnar fracture by LCP with iliac bone graft**.**

3.4 Delayed union

In 2 cases (10%). Delayed union is considered if the fracture did not start bridging callus formation at or after four months. Delayed union alone occurred in one patient (5%) and was associated with deep wound infection in one patient (5%). The second patient was a 51-year-old diabetic and hypertensive female with a history of RTA. One month later she was presented with a discharge sinus through the wound scar, with high ESR, CRP and WBC. The wound was managed by multiple debridement and irrigation for 3 weeks. Swab cultures were taken, and proper antibiotics were given. The healing was delayed, the union started to appear in the fifth month, and the infection disappeared after the removal of the plate by a standard procedure**.**

3.5 Superficial wound infection

In 1 case (5%). A 50-year-old diabetic female, 7 days post-operative developed redness, hotness around the wound edges, and serogenous discharge from the wound, gram stain and culture swab were taken and showed no growth. Debridement and 2ry wound closure in addition to IV antibiotics follow up with daily dry dressing and serial ESR, CRP and CBC were done till infection was controlled, the wound was healed, and the union started to appear at the fourth month**.**

3.6 Chronic regional pain syndrome

In one case (5%). Sings of union appeared in the fourth month with chronic pain in the forearm while lifting heavy weights**.**

4 .Discussion

Aseptic nonunion remains a significant late complication of diaphyseal forearm fractures with reported incidences ranging from 2% to 10%. [1,3,4]. Treatment of nonunion of the forearm remains a matter of debate. Several surgical techniques: internal fixation with bridging plate, intramedullary nailing, and external fixation have been recommended [12,13]. Successful surgical treatment of nonunion of the forearm requires several considerations: time to receive the appropriate care with the initial injury, the number of previous surgeries, the presence of infection, the length of the bone defect and finally the type of fixation method. The surgical treatment aims to reestablish the length of both the radius and ulna, restore their anatomy and quickly recover the function of the upper limb and hand [14]. Diaphyseal fracture nonunion of upper limb, including the forearm, must be differentiated from diaphyseal nonunion of lower limb fractures because the main constraints are related to rotation and distraction and not to compression [15]. This fundamental constitutes the basis of diaphyseal fractures treatment of the forearm, which will block rigidly the shearing forces and rotation. In the results of our study and those reported in the literature, the treatment of nonunion of diaphyseal forearm fractures by bone graft and fixation with a bridging plate gives excellent results if the principles of this technique are adhered. These principles include freshening the non-viable tissue, removal of the defective osteosynthesis material, restoration of alignment, length and rotation. We have found in our study that oligotrophic nonunion are more common than hypertrophic or atrophic nonunion and that the high rate of nonunion for ulna is likely to be explained by the use of the intramedullary pinning to treat fractures of the ulna. Some authors have shown that stabilization of forearm fractures with intramedullary Kirschner wire and one-third tubular plate may have a high risk of nonunion because of the fastening failure [16]. On the other hand, no study has shown a significant difference in risk between ulna and radius that leads to nonunion [5,17]. Some authors report the importance of the use of intramedullary nailing in the treatment of nonunion of the forearm, a technique in which we have no experience, and we believe that this technique provides relative stability and

lack of rotation control [14,18]. The locked intramedullary nail treatment is commonly used in the treatment of nonunions of long bones of the lower limb [19]. The authors emphasize the possibility of curing nonunion of the forearm by an intramedullary nailing, profiting from closed focal spot fixation which would have union rates comparable to those using compression plates [14]. We think that we need to be more critical and do not advise the treatment of forearm nonunion by nailing, especially as some authors propose to associate an intramedullary nailing to a cortical cancellous bone graft with an open focal spot to improve anatomical results, particularly in case of atrophic nonunion [7,20]. In this case, we lose all the advantages of closed focal spot fixation; however, the locked nail seemed to be indicated only for hypertrophic diaphyseal nonunion without bone graft. Concerning the external fixation method, is commonly used in the treatment of septic nonunion and its effectiveness is recognized. This type of treatment often uses the Ilizarov external fixator [21]. Its proponents believe that through it they stop septic risks and periosteal devitalization, but in reality, it suffers from some side effects such as: difficulties in blocking rotation, obtaining an anatomical reduction, poor fixation and insufficient focal spot compression, as well as complications including nerve and vascular damage during the installation of sheets. It is important to compare the two types of nonunion, the one which only concerns one forearm bone and the one which concerns a dual radius and the ulna nonunion whose impact on the function is different. The choice of bone graft is still a controversial subject [22,23], since autologous bone graft is often performed in orthopaedic surgery for the treatment of nonunion, and even in the treatment of fractures of the forearm to accelerate healing as well as to prevent nonunion. This attitude remains controversial in the literature [24,25]. Furthermore, the iliac crest is the most common donor site for obtaining an autologous bone graft. These autografts have advantages, like the absence of risk of autoimmune response and disease transmission. Nicoll [12] was the first to report the value of use of corticocancellous autograft in nonunion of the forearm, he recommended this technique in the absence of infection and the existence of a bone gap between the two fracture ends of less than 50mm [26], this does not preclude that there are authors who believe that osteomuscular decortication is sufficient and can replace the bone graft since this latter can cause morbidity of the engraftment site [7]. Ramoutar et al [27] showed that the usual use of autologous bone graft was not necessary, and in their comparative study showed that the union ratio without the use of bone graft was 94.6% while adding bone graft let's have a union ratio of 95%, without any difference ($p = 0.67$). This standard technique using a bone plate and an iliac graft is less effective in the treatment of long defects. It is particularly less effective in bone defects over 60 mm, and which have operational difficulties for the management of the iliac graft so as to obtain sufficient compression and a normal length due to the physiological bowing (curvature) of the bone [26]. Ring et al. [23] showed that a non-vascularized autologous bone graft led to union in the case of atrophic nonunion with bone loss up to 6 cm while, Dos Reis et al [28] showed, in a series of 31 patients, that treatment with corticocancellous bone graft and fixation with a plate for atrophic and hypertrophic nonunion led to excellent radiological and functional results. However, the treatment remains controversial for bone defects varying between 6cm and 10.5 cm [26,29]. Davey et al emphasized the limits of the use indications concerning non-vascularized bone graft for bone defects exceeding 6 cm. In order to be successful, this surgical technique depends on the union and healing of corticocancellous bone grafts. Our results are in agreement

with other reports published in the literature. We had only minimal complications and a satisfactory consolidation rate of 95% compared to the literature which varies between 91% and 100%. We obtained excellent functional end results. Therefore, this surgical method is, from our point of view, an excellent technique to treat forearm diaphyseal fracture nonunion. Finally, the current therapeutic approach prevents the occurrence of nonunion. This rule is especially applied to fractures involving both bones of the forearm, which are conventionally treated by plate osteosynthesis. It seems clear that the absence of bone formation around the third or the fourth month pushes us to take an almost early preventive therapeutic approach with a possible bone intake and a change in the fixation if it seems essential.

5 .Conclusion

Surgical management steps for non-union with decortication, bone autograft and stabilization with bridging plate have achieved satisfactory results in our series.

Funding Sources: There was no support for this study from any governmental, private, or non-profit Organization**.**

Conflicts of interest: No competing interests **.**

References

1. Anderson LD, Sisk D, Tooms RE, Park WI. Compression-plate fixation in acute diaphyseal fractures of the radius and ulna. *J Bone Joint Surg.* (3rd) 1975;3-A:7–287.

2. Stern PJ, Drury WJ. Complications of plate fixation of forearm fractures. *Clin Orthop Relat Res.* 1983; 175:25–9.

3. Ross ER, Gourevitch D, Hastings GW, Wynn-Jones CE, Ali S. Retrospective analysis of plate fixation of diaphyseal fractures of the forearm bones. *Injury.* 1989; 4:211–4.

4. Hadden WA, Reschauer R, Seggl W. Results of AO plate fixation of forearm shaft fractures in adults. *Injury.* 1983; 1:44–52.

5. Kloen P, Wiggers JK, Buijze GA. Treatment of diaphyseal non-unions of the ulna and radius. *Arch Orthop Trauma Surg.* 2010; 130:1439–45.

6. Richard MJ, Ruch DS, Aldridge JM. Malunions and nonunions of the forearm. *Hand Clin.* (3rd) 2007; 2:235–43.

7. Judet R, Judet J, Orlandini J, Patel A. La décortication ostéomusculaire. *Rev Chir Orthop.* 1967; 53:43–63.

8. Muller M, Nazarian S, Koch P, Schatzker J. *The comprehensive Classification of fractures of long bones.* Springer; Berlin: 1990.

9. Corrales LA, Morshed S, Bhandari M. al . Variability in the Assessment of Fracture-Healing in Orthopaedic Trauma Studies. *J Bone Joint Surg.* 2008;90-A:1862–8.

10. Anderson LD,Sisk D,Tooms RE,Park WI 3rd (1975) Compression-plate fixation in acute diaphyseal fracture of the radius and ulna. J Bone Joint Sugar AM 3:7-287.

11. Ring D,Allendc C,Jafarnia K,Allende BT,Jupiter JB (2004) Ununited diaphyseal forearm fractures with segmental defects: Plate fixation and autogenous cancellous bone-grafting. J Bone Joint Sugar AM 11:2440-2445.

12. Nicoll EA. The treatment of gaps in long bones by cancellous insert grafts. *J Bone Joint Surg.* 1956;38-B:70–82.

13. Kamrani RS, Mehrpour SR, Sorbi R, Aghamirsalim M, Farhadi L. Treatment of nonunion of the forearm bones with posterior interosseous bone flap. *J Orthop Sci.* 2013; 18:563–8.

14. Hong G, Cong-Feng L, Hui-Peng S, Cun-Yi F, Bing-Fang Z. Treatment of diaphyseal forearm nonunions with

interlocking intramedullary nails. *Clin Orthop Relat Res.* 2006; 450:186–92.

15. McKee MD, Miranda MA, Riemer BL, Blasier RB, Redmond BJ, Sims SH et al. Management of humeral nonunion after the failure of locking intramedullary nails. *J Orthop Trauma.* 1996; 10:492–9.

16. Mikek M, Vidmar G, Tonin M, Pavlovcic V. Fracture-related and implant-specific factors infuencing treatment results of comminuted diaphyseal forearm fractures of the forearm bones. *Injury.* 2004; 4:211–4.

17. Cai RB. Analysis of 81 cases of nonunion of forearm fracture. *Chin Med J (Engl)* 1983; 1:29–32.

18. Hofmann A, Hessmann MH, Rudig L, Kuchle R, Rommens PM. Intramedullary osteosynthesis of the ulna in revision surgery. *Unfallchirurg.* 2004; 7:583–59

19. Johnson EE, Marder RA. Open intramedullary nailing and bone-grafting for non-union of tibial diaphyseal fracture. *J Bone Joint Surg.* 1987;69-A:375–80.

20. Saka G, Saglam N, Kurtulmus T, Avci CC, Akpinar F. Treatment of diaphyseal forearm atrophic nonunions with intramedullary nails and modified Nicoll's technique in adults. *Acta Orthop Traumatol Turc.* 2014;48(3):262–70.

21. Ilizarov GA, Kaplunov AG, Degtiarev VE, Lediaev VI. Treatment of pseudarthroses and ununited fractures, complicated by purulent infection, by the method of compression-distraction osteosynthesis. *Ortop Travmatol Protez.* 1972; 33:10–4.

22. Jupiter JB, Gerhard HJ, Guerrero J, Nunley JA, Levin LS. Treatment of segmental defects of the radius with use of the vascularized osteoseptocutaneous fibular autogenous graft. *J Bone Joint Surg.* 1997;79-A:542–50.

23. Ring D, Allende C, Jafarnia K, Allende BT, Jupiter JB. Ununited diaphyseal forearm fractures with segmental defects: plate fixation and autogenous cancellous bone-grafting. *J Bone Joint Surg.* 2004;11-A:2440–5.

24. Wei SY, Born CT, Abene A, Ong A, Hayda R, De Long WG., Jr Diaphyseal forearm fractures treated with and without bone graft. *J Trauma.* 1999; 6:1045–8.

25. Wright RR, Schmeling GJ, Schwab JP. The necessity of acute bone grafting in diaphyseal forearm fractures: a retrospective review. *J Orthop Trauma.* 1997; 4:288–94.

26. Davey PA, Simonis RB. Modification of the Nicoll bonegrafting technique for nonunion of the radius and/or ulna. *J Bone Joint Surg.* 2002;84-B:30–3.

27. Ramoutar DN, Rodrigues J, Quah C, Boulton C, Moran CG. Judet decortication and compression plate fixation of long bone non-union: Is bone graft necessary? *Injury.* 2011;42(12):1430–4.

28. Baldy Dos, Reis F, Faloppa F, Alvachian Fernandes HJ, Manna Albertoni W, Stahel PF. Outcome of diaphyseal forearm fracture-nonunions treated by autologous bone grafting and compression plating. *Ann Surg Innov Res.* 2009; 1:5

29. Moroni A, Rollo G, Guzzardella M, Zinghi G. Surgical treatment of isolated forearm non-union with segmental bone loss. *Injury.* 1997; 8:497–504.