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Araştırma / *Research Article*

Retrospective Evaluation of Adult Diaphyseal Forearm Fractures Result In The Treatment Of Plate Osteosynthesis

Yetişkin Önkol Diyafiz Kırıklarının Düşük Temaslı Dinamik Kompresyon Plağı ile Tedavi Sonuçları

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ABSTRACT

Objective: *In this study we aimed to present the midterm clinical and radiological outcomes of low contact dynamic compression plate fixation of adult forearm fractures.*
Method: *The study included 104 patients with adult forearm fractures who were compatible with the inclusion criteria and have attended the last follow up.*
Results: *The mean time to union was 10,82 weeks. Mean Disabilities of the Arm, Shoulder and Hand (DASH) score was 12.75. There were no cases with implant failure, mechanical irritation, refractures and radioulnar synostoses. 36 patieents were evaluated as perfect, 34 patients as good, 34 patients as acceptable outcomes. No unacceptable outcomes have been obtained.*
Conclusion: *Adult forearm diaphyseal fractures are challenging cases in terms of treatment rehabilitation and complications. In order to prevent medicolegal consequences soft tissues and periosteum must be handled gently and anatomic, rigid, and stable reduction must be obtained in primary surgery. Open reduction and internal fixation with LC DCP' is the golden standart treatmen option for forearm diaphyseal fracture management and perfec radiologic and functional outcomes can be obtained with this method.*

Keywords: *radius, ulna, fracture, plate*

ÖZ

Amaç: *Bu çalışmada amacımız, 2009-2017 yılları arasında LC-DCP ile belirlediğimiz yetişkin önkol kırığı olan olgularımızın uzun dönem sonuçlarını literatürdeki diğer çalışmalarla karşılaştırmayı amaçladık.*
Yöntem: *Çalışmaya önkol diyafiz kırığı olan 104 hasta dâhil edildi. Hastaların 80'i (%76,92) erkek, 24'ü (%23,07) kadındı. Kırıkların etiyolojik dağılımında; 56 düşme (%53,84), 32 trafik kazası (%30,76), 8 iş kazası (%7,69), 8 darp (%7,69) sonucu kırık gelişmişti.*
Bulgular: *Ortalama kaynama süresi 10,82 hafta (8-20) haftaydı. Hastaların ortalama Disabilities of the Arm, Shoulder and Hand (DASH) skoru ortalaması 12,75 (3,3-38,8) olarak değerlendirildi. İmplant yetmezliği, mekanik irritasyon, implant kırılması, refraktür ve radioulnar sinostoz gelişen hasta olmadı. Grace-Eversman'nın fonksiyonel ve kaynama yönünden değerlendirme kriterlerine göre 36 hastada (%34,61) kusursuz, 34 hastada (%32,69) iyi, 34 hastada (%32,69) kabul edilebilir sonuçlar elde edilirken, kabul edilemez sonuç yoktu.*
Sonuç: *Önkol diyafiz kırıklarının rekonstrüksiyonunda tam anatomik redüksiyon öncelikli amaçtır. Önkol kırıklarında yetersiz anatomik redüksiyon önkol rotasyonunu etkileyen önemli bir faktördür. Önkol diyafiz kırıklarının cerrahi tedavisinde LC-DCP belirleme materyalleri ile kusursuz radyolojik ve fonksiyonel sonuçlar elde edilmektedir.*

Anahtar kelimeler: *radius, ulna, kırık, plak*

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INTRODUCTION

The forearm has a distal joint with the wrist and a proximal joint with the elbow. Due to the spatial alignment, their positions are important in both wrist and elbow functions. Therefore, perfect functioning of the upper extremity depends on a perfect forearm function. Angular deformity in the coronal or sagittal plane of the radius and ulna disrupts rotation. This has a clinically negative effect which is reflected in the functions of the hand, wrist and upper extremities. Therefore, forearm fractures should be accepted as intra-articular fractures [1]. When its functions and anatomic structure are taken into consideration, it could be more accurate to evaluate the forearm as a joint [2]. The forearm diaphysis encompasses the area from the radius and ulna distal metaphyseal border in the distal and the area between the tuberositas radii in the radius in the proximal.

In addition to weakened hand functions and loss of movement in inadequately treated forearm diaphyseal fractures, these problems can also cause psychological problems [1,3]. Radius and ulna fractures are most often seen after a fall [2,4]. Technology developed in recent years and the increase in average life expectancy have increased the incidence of more complex forearm fractures seen in adults [2,3].

The radius and ulna each operate as a separate functional unit within the forearm. In daily use, the radius and ulna are exposed to excessive torsional forces. Therefore, the fixation of these fractures to be applied must ensure the strength and stability to resist these forces. In contrast to the conservative treatment applied to pediatric forearm fractures, conservative approach is not an acceptable treatment method in adults because of the torsional and shear effects of the muscles at the forearm level.

To achieve good functional results and sufficient joint range of movement in the surgical treatment of forearm fractures, accomplishment of full anatomic fixation together with internal rigidity allowing early movement are very important considerations [2,5]. The provision of anatomic reduction, axial alignment, rotational stability and proximal-distal radioulnar joint integrity are the basis of fracture reduction [5]. Many internal fixation materials (intramedullar nailing, dynamic compression plates [DCP], external fixators, low-contact dynamic compression plates [LC-DCP]) are currently used for this purpose [1-3]. Plate-screw osteosynthesis is the most widely used and accepted method in the surgical fixation of diaphyseal fracture of the forearm as it allows for full anatomic reduction and sufficient stability [5-17]. In this study we aimed to present the radiological and functional results of patients treated with low-contact dynamic compression plate applied for a forearm diaphyseal fracture.

MATERIAL and METHOD

The study included 104 adult patients treated with open reduction and internal fixation with LC-DCP's because of a diaphyseal fracture of the radius, ulna or both bones between 2009 and 2017. Patients with a displaced closed diaphyseal fracture or a Type 1-2 open fracture of forearm were included in the study. Patients with a Type 3 open fracture, open epiphyseal line, concomitant ipsilateral extremity fracture, pathological fracture, or a defective fracture requiring reconstructive procedures were excluded from the study. In the first evaluation of each patient, standard forearm anteroposterior and lateral X ray graphies were obtained. All of the fractures were classified according to the AO/OTA classification system. Informed consent was obtained from all of the patients preoperatively. Ethics committee approval (decision no: B.30.2.ATA.0.01.00/92 and dated 06. 07.2013) was granted from Ethics Committee of Ataturk University.

There were 10 Type 1 or 2 open fractures and 94 closed forearm fractures. The study population consisted of 80 (76.92%) males and 24 (23.07%) females. Median age of the patients were 36.28 years (range,

Table 1. Patients' medical information and demographic distribution.

	LC-DCP Plak
Number of patients	104
Gender distribution (n)	
Female	24 (23.07%)
Male	80 (76.92%)
Average age	36.28 (18-63)
Trauma etiology (n)	
Traffic accident	32 (30.76%)
Fall	56 (53.84%)
Work injury	8 (7.69%)
Sports injury	- (-%)
Assault	8 (7.69%)
Additional Trauma	
No additional trauma	76 (73.07%)
Additional fracture	28(26.92%)
Fractured bone	
Radius	34 (32.69%)
Ulna	34 (32.69%)
Both radius and ulna	36 (34.61%)
Fractured forearm	
Right	58 (55.76%)
Left	44 (42.30%)
Both Right and Left	2 (1.92%)
AO/OTA fracture type (n)	
Type A1	20 (19.23%)
A2	24 (23.07%)
A3	12 (11.53%)
Type B1	16 (16.7%)
B2	8 (7.69%)
B3	14 (13.46%)
Type C1	4 (3.84%)
C2	2 (1.92%)
C3	4 (3.84%)
Preoperative Compartment Syndrome	2 (1.92%)
Closed fracture (n)	104 (100%)
Type 1-2 Open fracture (n)	0 (0%)
Time Until Operation (hour)	17.23 (6-48)
Anesthesia Type	
Regional Anesthesia	50 (48.07%)
General Anesthesia	54 (51.92%)

18-63 years). Etiologic mechanisms of the fractures were determined as a fall from a height in 56 (53.84%), traffic accidenst in 32 (30.76%), workplace accidents in 8 (7.69%) and assaults in 8 (7.69%). In 96 patients there was no additional trauma. Pathologies concomitant to the forearm fractures were femur fractures in 2, acetabulum fractures in 2, mandibular fractures in 2, and tibial fractures in 2 patients.

The forearm fractures involved only ulna in 34, and radius in 34, and both radius and ulna in 36 cases. The fracture was in the right forearm in 58 (55.76%), the left forearm in 44 (42.30%) and both in 2 (1.92%) patients. According to the AO/OTA classification system, 20 patients were recorded as 22A1, 24 as 22A2, 12 as 22A3, 16 as 22B1, 8 as 22B2, 14 as 22B3, 4 as 22C1, 2 as 22C2, and 4 as 22C3. In the neurovascular examination, no pathology was determined in any patient.

At the time of first presentation, closed reduction and plaster cast fixation was not applied to any patient. In the period from first evaluation to surgery, a long-arm splint was applied as temporary fixation and during this period, as a routine practice anti-edema treatment, analgesic support and extremity elevation were applied. The median time to surgery was mean 17.23 hours (range, 6-48 hours). Regional anesthesia was used in 50 and general anesthesia in 54 patients. The demographic data of the patients are shown in Table 1.

Surgical Technique

All the patients were operated in supine position with their arms on an arm board. For a radius fracture, the Henry approach was used, extending between the radial styloid in the forearm volar region and the biceps tendon felt in the antecubital region. For an, a transcutaneous approach was used extending along the edge of the ulna felt below the skin.

In fractures of both the radius and ulna, ulna was fixed primarily. As the ulna is the touchstone of forearm length, fixation in the practical application was started with the ulna. ulna fracture It was thought that maximum bowing and the interosseous distance could be created more easily when forearm length was achieved, so in cases with fractures of both bones, fixation of the ulna was applied first, regardless of the comminution status of the fracture. In multi-fragmented fractures, the length of the fractured side was determined based on the radiological images of the unaffected extremity.

During fracture fixation, the periosteum was protected and not stripped as far as possible. Taking the AO principles as the basis in fracture fixation, after applying the compression screws to the two holes closest to the fracture, reduction was obtained with the reduction clamp, the screws were tightened and compression was created, then fixation the bone was provided as far as possible with locking screws.

For fracture fixation of both the radius and the ulna, 3.5mm LC-DCP plates were used. The fracture was fixed in a way so that at least 6 cortex screws could be applied to the proximal and distal parts. In fractures with a free fragment which was large enough to be held with a butterfly screws, before placement of the plate, the free fragment was fixed with lag screws in a way not to obstruct the plate.

After fixation, a final check of the reduction was made under fluoroscopy, a negative pressure drain was applied to each patient and after closure of the wound, a long-arm splint was applied.

RESULTS

Average follow-up period was 91.19 weeks (range, 12-170 weeks). Average perioperative blood loss was 36.38 ml (range, 7-150 ml). The average time to bone union was mean 10.82 weeks (range, 8-20 weeks). The average operating time was 44.67 mins (range, 17-85 mins) and the average length of hospital stay was 3.65 days (range, 2-10 days).

Autogenous bone graft was used in 6 (5.76%) patients and there was no requirement for graft in 98 (94.23%) patients. Any iatrogenic neurovascular damage did not occur in any patient. All of the patients had been maintained in short arm splint for 3 weeks. Passive joint range of movement exercises were performed for the next 3 weeks and from the 6th week onwards, active exercises were allowed.

According to the evaluation of the functional and bone union results using the Grace-Eversmann criteria (18), the results were excellent in 36 (34.61%), good in 34 (32.69%), acceptable in 34 (32.69%) and there were no unacceptable results. The average DASH score (19) was 12.75 (range, 3.3-38.8). Complete bony union was noticed in all of the cases according to the Anderson Union Evaluation Criteria (20). Delayed union or non-union was not detected in any case. According to the Anderson Functional Evaluation Scale (20), the results were excellent in 100 (96.15%), and good in 4 (3.84%) patients; while any moderate or poor results were not recorded (Figure 1).

Figure 1. A. Radıus, ulna comminuted fracture, B. Radius, ulna fracture with long arm splint, C. Radius, ulna union after treatment lateral view, D. Radius, ulna union after treatment AP view.

Table 2. Assesment of post treatment and surgery data of patients in our study.

	LC-DCP
Follow-up period, (week)	91.19 (12-170)
Surgery period (minute), (range)	44.67 (17-85)
Graft Need	
No need	98 (94.23%)
Autogen Graft	6 (5.76%)
Allograft	0 (0%)
Immobilization period (day), (range)	3.19 (1-7)
Grace-Eversman ratio (n,%)	
Perfect	36 (%34.61)
Good	34 (%32.69)
Acceptable	34 (%32.69)
Not acceptable	0 (%0)
DASH score (range)	12.75 (3.3-38.8)
Anderson Union Assesment	
Union	104 (100%)
Delayed union	0 (0%)
Nonunion	0 (0%)
Anderson Functional Assesment Scale	
Excellent	100 (96.15%)
Good	4 (3.84 %)
Moderate	0 (0%)
Bad	0 (0%)
Union period (week) (range)	10.82 (8-20)
Post Follow up ROM (degree) (range)	
Supination	75.23 (65-80)
Pronation	85.03 (74-90)
Grip strength (kgw), (range)	54.30 (30-110)
Bleeding during surgery (ml), (range)	36.38 (7-150)
Complication ratio	0 (%0)
Elbow joint ROM (degree) (range)	
Flexion	142.71 (123-145)
Extension	0.69 (0-5)
Wrist joint ROM (degree) (range)	
Dorsiflexion	78.44 (74-80)
Volar flexion	74.5 (65-79)
Radiological Evaluation, (range)	
MRI	14.4 (12-17)
MRIL	%58.5 (52-70)

There was no requirement for any additional fixation method during follow-up in any patient and any implant irritation or failure was not observed in any patient. After union, the implant was removed on request from 10 patients who had no subjective complaints. The implants were removed at an average of 16 months (range, 12-30 months) and any refracture was not observed in any of the patients where the implant was removed.

Grip strength was measured with hand dynamometry, and was determined as mean 54.30 KGW (range, 30-110 KGW) in the fractured arm and mean 59.83 KGW (range, 35-129 KGW) in the healthy contralateral hand. No statistically significant difference was determined between the two sides ($p<0.05$).

Supination was evaluated as mean 75.23° (range, 65°-80°) in the treated arm and mean 79.96° (range, 78°-80°) in the healthy arm. Pronation was evaluated as mean 85.03° (range, 74°-90°) in the treated arm and mean 90° (range, 90°-90°) in the healthy forearm. Elbow joint flexion was evaluated as mean 142.71° (range, 123°-145°) in the treated arm and mean 144.38° (range, 143°-145°) in the healthy forearm. Elbow joint extension was evaluated as mean 0.69° (range, 0°-5°) in the treated arm and mean 0.11° (range, 0°-3°) in the healthy forearm. Wrist joint flexion was evaluated as mean 74.5° (range, 65°-79°) in the treated arm and mean 75.01° (range, 74°-79°) in the healthy forearm. Wrist joint extension was evaluated as mean 78.44° (range, 74°-80°) in the treated arm and mean 79.92° (range, 78°-80°) in the healthy forearm. The results are shown in Table 2.

DISCUSSION

The primary aim of the fixation of forearm diaphyseal fractures is full anatomic reduction. The radius curve and continuity of the interosseous distance must be provided in forearm diaphyseal fractures [2,21,22]. Insufficient anatomic reduction in forearm fractures is an important factor affecting forearm rotation [23]. There are studies which have reported that when the coronal curve of the radius is impaired, the forearm rotation movement is impaired [24-27]. So achieving anatomic reduction and a stable and rigid fixation is imperative in the open fixation of foream diaphyseal fractures. However, some studies where

intramedullar fixation has been applied have reported that even if full anatomic reduction is not provided, good functional results can be obtained.

Open reduction and internal fixation (LC-DCP) is currently the most widely used and accepted fixation method in the treatment of forearm diaphyseal fractures. Radius and ulna is curved in both the sagital and coronal planes. In the application of plate osteosynthesis, it is generally aimed to achieve alignment in the coronal plane, disregarding the curves in the sagittal plane. During the operation, if sufficient contact of the plate in the distal or proximal parts may not achieved, then the plate may not come entirely in contact with the bone in the transverse axis. Implants can be developed suitable to the anatomic curvatures or the fracture level in both planes.

There are few comparative studies in the literature related to the fixation of forearm fractures [28,29]. The majority of these comparative studies have examined and evaluated union of the fracture, the forearm pronation and supination degrees obtained at the final follow-up and complication rates. The results of fixation obtained in the current study and the comparisons with studies in literature are shown in Table 3. However, there is no published study which explains the relationship between the extend of forearm supination and pronation obtained with the amount of anatomic reduction provided with adequate and necessary borders of maximum radial curve reconstruction. In addition, the union and functional evaluations made in recent studies were not seen to sufficiently meet the Grace-Eversmann and Anderson criteria which have been used in all the studies. As functional results are important, there can be considered to be a need for an updated evaluation system including the amount of interosseous membrane damage and the degrees to which the distal and proximal radioulnar joints are affected.

The use of autogenous bone graft in the primary surgery for the forearm fractures is controversial. Some studies in the literature have recommended the use of non-vascularised, corticocancellous autogenic bone grafts for forearm fractures with a defect or where pseudoarthrosis has developed [30-32]. There are also studies which have reported that the use of autogenic bone graft during primary fixation of fragmented forearm fractures has reduced the time to union [33,34]. Burwell and Chaney recommended that autogenic bone graft should be used in cases where rigid fixation cannot be achieved [35]. In a retrospective study by Wei et al, which included 64 patients, 25% of which were fragmented fractures, it was reported that the use of graft did not change the union rates or time to union in primary forearm diaphyseal fractures [17]. There are potential risks to the use of autogenic bone graft, such as donor site morbidity [36], late integration of the graft with the forearm bone and infection [37]. In this study, autogenous corticocancellous bone graft was used in 6 patients with comminuted fractures, and it was considered that a rigid fixation could not be provided.

Implant removal in forearm fracture surgery after union is a matter of debate [30,31]. Higher refracture rates have been reported in open, fragmented, fractures developing after high-energy trauma, in fragmented fractures with insufficient compresson and reduction and in the presence of another fracture in the same extremity [38,39]. Implant removal at least 8 months postoperatively has been reported to reduce the refracture rates [38,39]. In the current study, the implant was removed after bone union due to patients' requests in 10 cases, although the patients had not subjective complaints. No refracture was observed during follow-up in any of these patients. Apart from the cases of pathology associated with the fracture (eg, irritation, infection, pseudoarthrosis), removal of the implant after bone union should not be considered necessary in forearm diaphyseal fractures.

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