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INTERNAL FIXATION OF BOTH BONES FOREARM FRACTURES COMPARISON OF LOCKED COMPRESSION VS LIMITED CONTACT DYNAMIC COMPRESSION PLATES

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Abstract

Background: Forearm function, particularly pronation and supination, depends on the radius's and ulna's connection. Symptoms of malunions might make this joint less effective. Almost of adult forearm fractures including both bones require surgical treatment. Rigid fixation will help restore the natural alignment of the radius and ulna.

Patients and Methods: The purpose of this prospective randomized comparative trial was to determine the efficacy of two devices in treating 50 forearm fractures in 25 patients (12 patients with LCP and 13 patients with LC-DCP). Patients having a minimum follow-up of 6 months had an average age of 32 (range: 16–55 years). At the most recent follow-up, the patients' fracture union, function, and complications were evaluated.

Results: There was no statistically significant difference in the two groups' grip strength or range of motion. Delay in union was seen in one case (LC-DCP group). One patient in each group had oral antibiotics and supportive care for a superficial wound infection; one patient with LCP had an intravenous antibiotic regimen that effectively cured a deep wound infection and osteomyelitis without the need for further surgery.

In conclusion, LCP is an effective tool for treating fractures of the forearm and both bones.

Aim of the study: The study was evaluate the efficacy of two compression plate methods for treating diaphyseal fractures in the forearm: locked compression plate (LCP) and limited contact dynamic compression plate (LC-DCP).

Keywords: Diaphyseal, forearm, limited contact dynamic compression plate, locking compression plate, radius and ulna.

Introduction

Definition The forearm is crucial for the hand's spatial location because it allows the wrist and elbow to extend and flare, and it also allows the hand to pronate and supinate via the proximal and distal radioulnar joints. If the ulnar and radial shaft fractures are not appropriately treated, they might lead to substantial impairment. Fractures that happen between the radial neck and the intersection of the metaphysis and diaphysis, around 3 cm from the distal articular surface, are called radial shaft fractures. For purposes of this definition, a fracture of the ulnar shaft is one that happens between the distal portion of the coronoid and the ulnar neck.1-3

Epidemiology

The term "frequent fracture" is commonly used to describe breaks in the forearm shaft. Compared to distal radius fractures, diaphyseal forearm fractures occur ten times less often. There seems to be no change in the incidence of fractures in the forearm shaft over time. Depending on age and gender, the reported annual incidence in adults ranges from 0 to 4 per 10,000 people, with an average of 1.35 per 10,000. The yearly incidence of forearm shaft fractures is less than 2 per 10,000 persons, with men being the predominant age group, after the age of 20. Across the board, male patients account for a disproportionate share of forearm fracture cases in clinical trials. Between 63% and 91% of the population identifies as male. 1 The average age is between 24 and 37 years old, and most forearm fractures happen in the first 40 years of life. Men between the ages of fifteen and thirty-nine account for more than half of all fractures to the forearm shaft. Eighty percent of men's forearm fractures occur in this age bracket. Across all age groups, women continue to have a decreased risk of forearm shaft fractures. There is evidence that the seventh decade of life is the most common. 1

Anatomy of the forearm

In the field of osteology, there are bones like the ulna and radius, which are seen in figure (1). These bones connect to other bones like the humerus and carpi, respectively.

1.***Ulna*** A trochlear notch separates the olecranon and coronoid processes, two curved bones that make up the ulna's proximal end. A medial styloid process and a lateral head mark the distal end of the ulna.4

2. ***Radius*** At its most anterior, the radius has a head with a central fovea, a neck, and a proximal medial radial tuberosity, which is where the biceps tendon inserts. When fixing radial shaft fractures, it is crucial to restore the radial bow (and length) since the shaft is gently curved (convex laterally) and gets progressively larger distally. Carpal articular surface, ulnar notch, dorsal tubercle (Lister's tubercle, located at the level of the scapholunate joint), and lateral styloid process make up the distal radius. 4

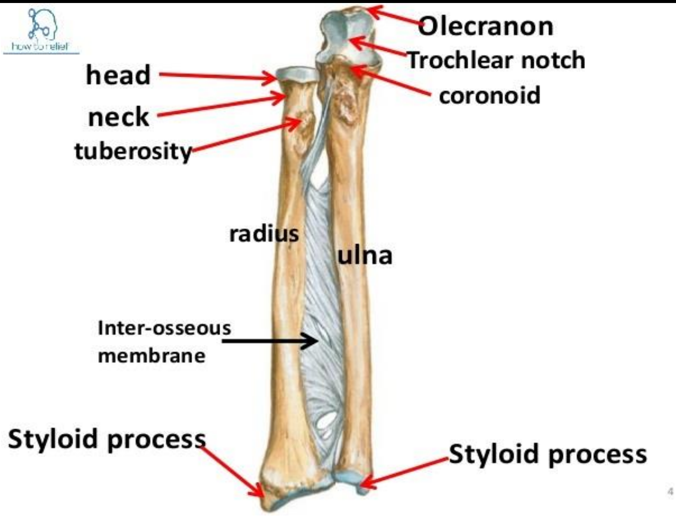

Figure (1) Schematic drawing of both bones forearm

A.In arthrology, the elbow joint is considered proximal and the wrist joint distal.
1. The most secure position is in supination for the distal radioulnar articulation.
2. joint is the radiocarpal joint, which is ellipsoidal in shape and which connects the triquetrum, lunate, and distal radius to the rest of the hand. A loose capsule covers it; the wrist is stabilized by ligaments, particularly the volar ligaments, and it is often placed at the level of the crease of the proximal wrist flexion. 3. The triangle fibrocartilage complex begins at the point where the radius is most ulnar and continues to the base of the fifth metacarpal via the caput ulnae and the wrist side of the ulna, as seen in figure (2):- A

- Dorsal and volar radioulnar ligaments
- Articular disc
- Prestyloid recess
- Meniscus homolog
- Ulnar collateral ligament. **4**

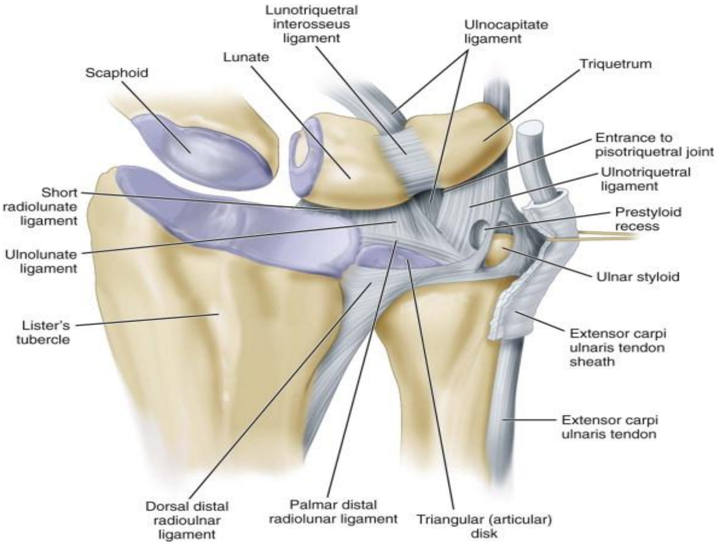

Figure (2) Schematic drawing of triangular fibrocartilage complex **6**

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A. ***Muscles***: arranged according to both location and function

1. **Volar flexors:** as shown in **figure (3).**

❖ Superficial flexors

- Pronator teres (PT)
- Flexor carpi radialis (FCR)
- Palmaris longus (PL)
- Flexor carpi ulnaris (FCU)
- Flexor digitorum superficialis (FDS) **4, 14**

❖ Deep flexors

- Flexor pollicis longus (FPL)
- Flexor digitorum profundus (FDP)
- Pronator quadrates (PQ) **4, 14**

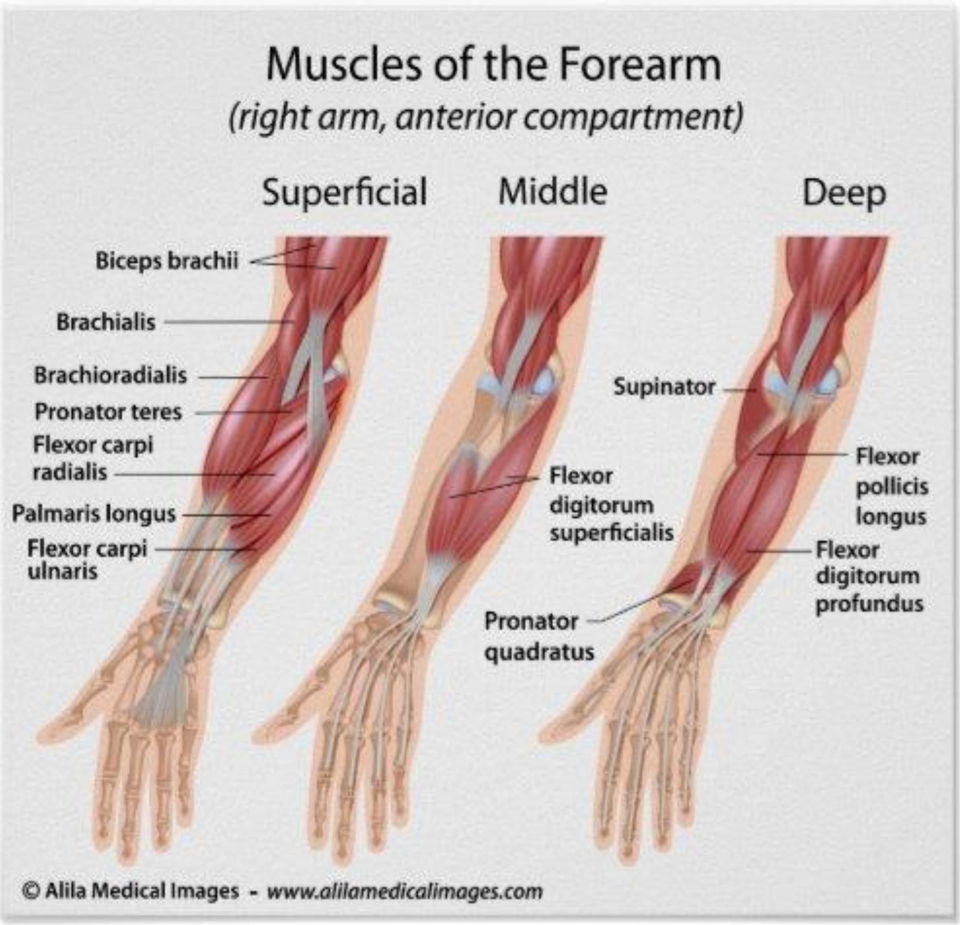

Figure (3) anterior muscles compartments of the forearm **7**

2. **Dorsal extensors:** as shown in **figure (4).**

❖ Superficial extensors

- Brachioradialis

- Extensor carpi radialis longus (ECRL)
- Extensor carpi radialis brevis (ECRB)
- Anconeus
- Extensor digitorum communis (EDC)
- Extensor digiti minimi (EDM)
- Extensor carpi ulnaris (ECU) **4, 14**

❖ Deep extensors

- Supinator
- Abductor pollicis longus (APL)
- Extensor pollicis brevis (EPB)
- Extensor pollicis longus(EPL)
- Extensor indicis proprius (EIP) **4, 14**

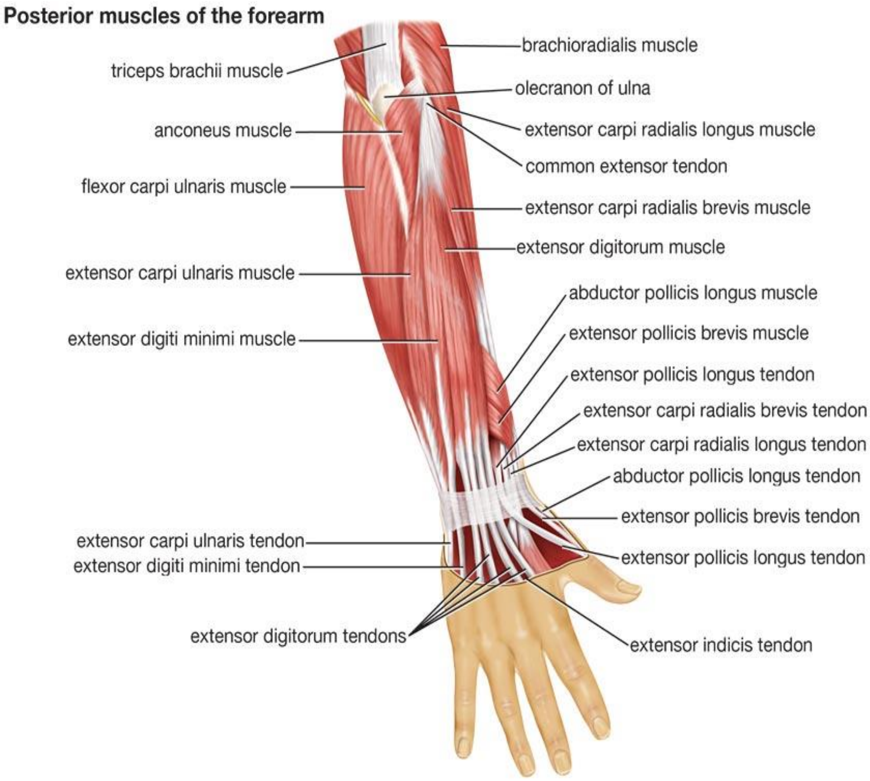

Figure (4) posterior muscles compartment of the forearm **8**

Section B: Nerves (as seen in Figure 5)

One such nerve is the root canal, which passes just in front of the lateral epicondyle. It splits into the anterior (BRACHIAL) and deep (BRACHIORADIAL) branches as it passes between the two bones. Outside of the movable wad, the PIN feeds all extensor muscles (ECRB, ECRL, and brachioradialis) and divides the supinator.In the distal portion of the forearm, between the brachioradialis and ECRL, the superficial branch of the radial nerve travels to the dorsal radial surface of the hand. 4Two, the median nerve is located just below the brachialis muscle and medial to the brachial artery at the elbow. The medial nerve of the forearm divides the pronator teres into two branches before passing between the FDS and FDP. It continues into the hand after becoming

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less deep at the flexor retinaculum. Aside from the flexor carpi ulnaris (FCU), it sends branches to every superficial forearm flexor. All deep flexors, with the exception of the ulnar half of the FDP, receive their supply from the anterior interosseous branch, which extends from the flexor pollicis longus (FPL) to the FDP.four, fourteen

3. The ulnar nerve is a branch of the sympathetic nervous system that originates in the forearm, feeds the forearm muscles, and travels between the ulnar and facial nerve plexuses. It innervates the ulnar half of the ulnar muscle, lays superficially at the wrist, and finally enters the hand by the Guyon's canal. 4

4. Cutaneous nerves: The lateral antebrachial cutaneous nerve begins at the elbow and extends laterally between the biceps and brachialis. It then continues lateral to the cephalic vein. 3The medial antebrachial cutaneous nerve is a special branch of the brachial plexus that originates from the medial cord.

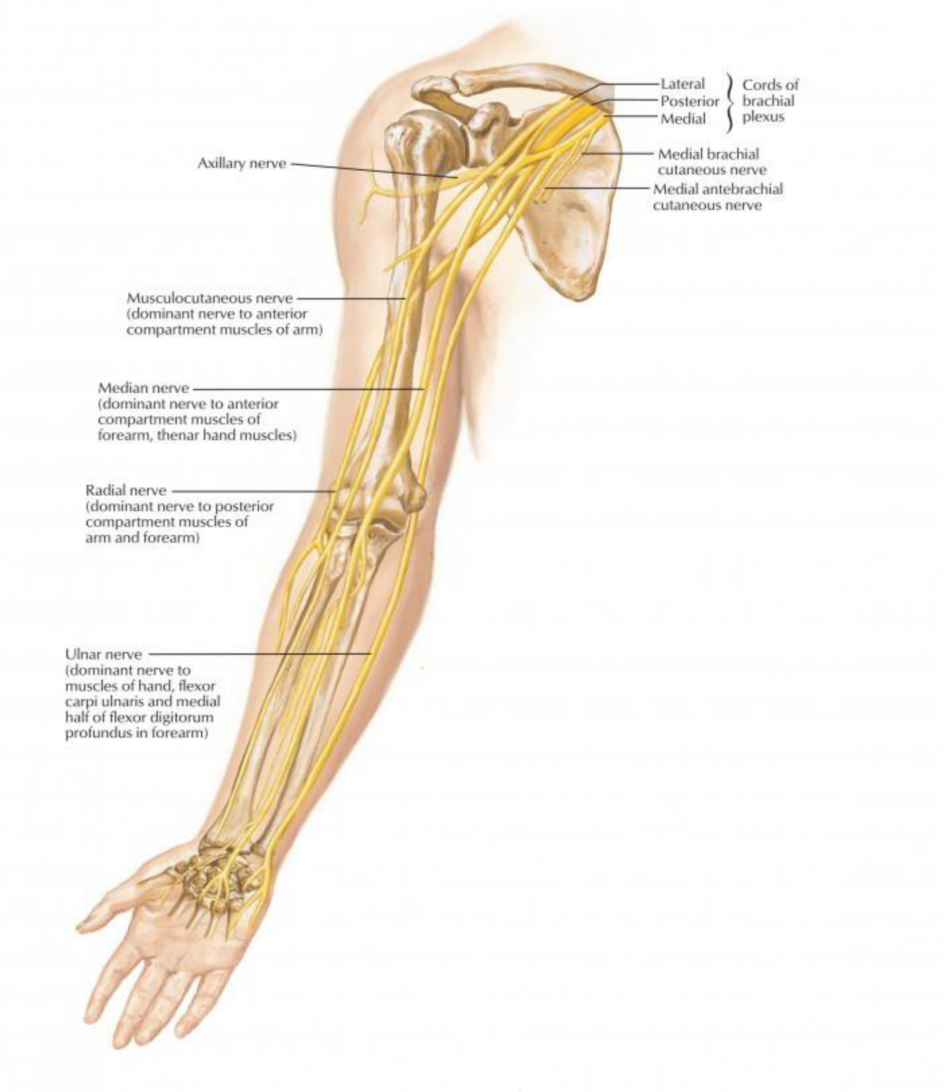

Figure (5) innervations of the forearm **7**

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Figure 6 shows the vessels (C).

1. The brachial artery: This artery passes through the cubital fossa before branching off into the radial and ulnar arteries at the level of the radial neck. 4

2.The radial artery, which branches out from the brachioradialis, first courses down the pronator teres. This line of action extends all the way to the wrist, where it meets the FCR (flexor carpi radialis). The forearm's recurrent radial and muscular branches are part of it. 4

Thirdly, the ulnar artery is the bigger of the two origins. The superficial flexors proximally, which are located between the FDS and FDP, encase this artery. The artery is located distally on the FDP, between the FDS and FCU tendons. Several nutritive and muscle arteries, as well as the common interosseous (which has anterior and posterior branches), and the anterior and posterior recurrent ulnar are forearm branches. 4

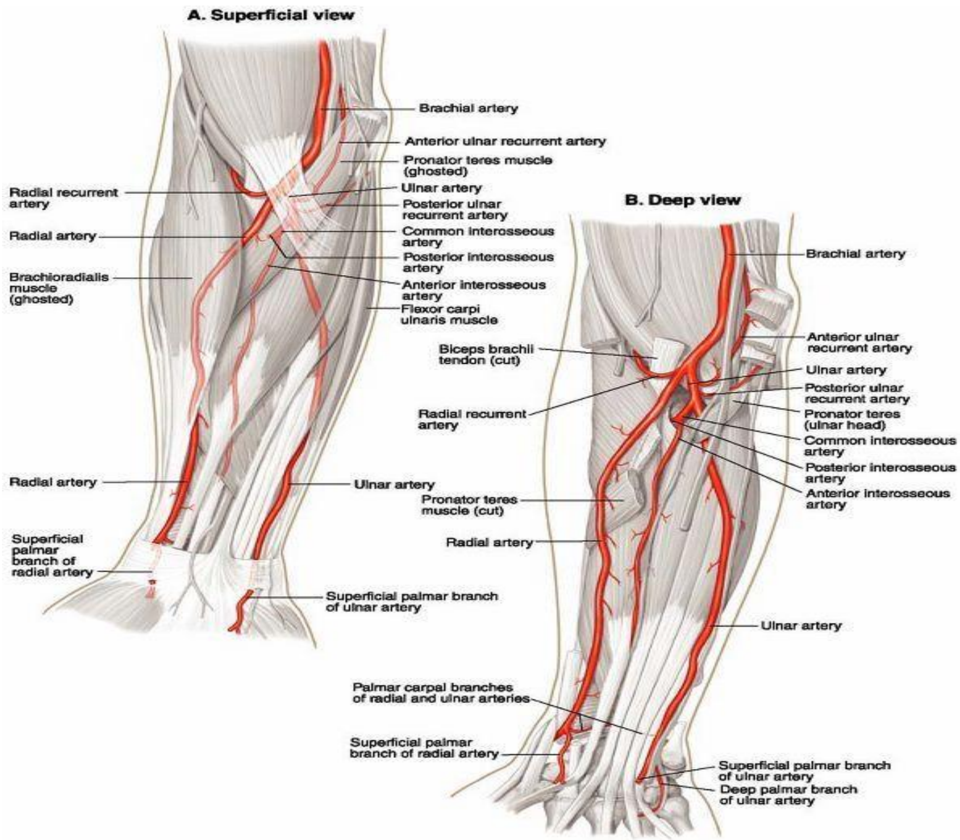

Figure (6) arterial supply of the forearm **7**

Pathophysiology

It is usual for the forearm bones to break at the shaft. The bones in a spiral fracture break at various levels due to a twisting force, which is typically caused by a fall on the hands. Both bones are transversely fractured at the same level due to an angular force. One bone, typically the ulna, can be transversely fractured in a direct impact. Pulling on the radius from the biceps and supinator muscles in the upper third, the pronator teres in the middle third, and the pronator quadratus in the bottom third can cause further rotation deformity. Impairment of circulation can occur as a result of forearm muscle compartment edema or bleeding. 9

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Pathoanatomy

Fractures of the forearm are prevalent among young men who sustain them in activities involving physical contact or in car accidents. This helps to clarify why open fractures of the forearm are so common—second only in frequency to those of the tibia. At the superior and inferior radioulnar joints, the radius and ulna articulate with one another and are held together by the interosseous membrane. In both pronation and supination, the radius pivots around the ulna, which is somewhat straight. For optimal functional outcomes, it is crucial to establish the ideal anatomical form (angulation and rotation) of the individual bones and the ideal anatomical connection between the forearm bones. The conservative treatment of fractures is complicated because of the several muscles linked to the bones of the forearm, which influence the post-injury location of the fracture fragments and have a tendency to move them. In proximal third radius fractures, the rotational forces are exerted by the biceps and supinator muscles, which are linked to the forearm bones proximally. Angular and rotational pressures are exerted distally by the pronator quadratus on the distal part of the radius and the pronator teres on the midshaft. Angulatory forces often displace ulnar fractures rather than causing them to rotate. Correctly restoring the relative length and rotation of the two bones is crucial to prevent the loss of supination and pronation. It is common for the ulna and radius to be fractured in forearm injuries. Dislocation of the opposite forearm bone at the proximal or distal radioulnar joint is a common consequence of isolated ulnar or radius fractures. One notable exception is nightstick fractures, which occur when the ulna is directly injured and just slightly displaced. 10

Classification

❖ **Descriptive**

- Closed vs. open
- Location (proximal, midshaft, distal)
- Comminuted ,segmental ,multifragmented
- Displacement
- Angulation
- Rotational alignment. **11**

❖ **AO classification** : shown in **figure (7)**

- Type A
  - Simple fracture of ulna (A1), radius (A2), or both bones (A3)
- Type B
  - Wedge fracture of ulna (B1), radius (B2), or both bones (B3)
- Type C
  - Complex fractures. **11**

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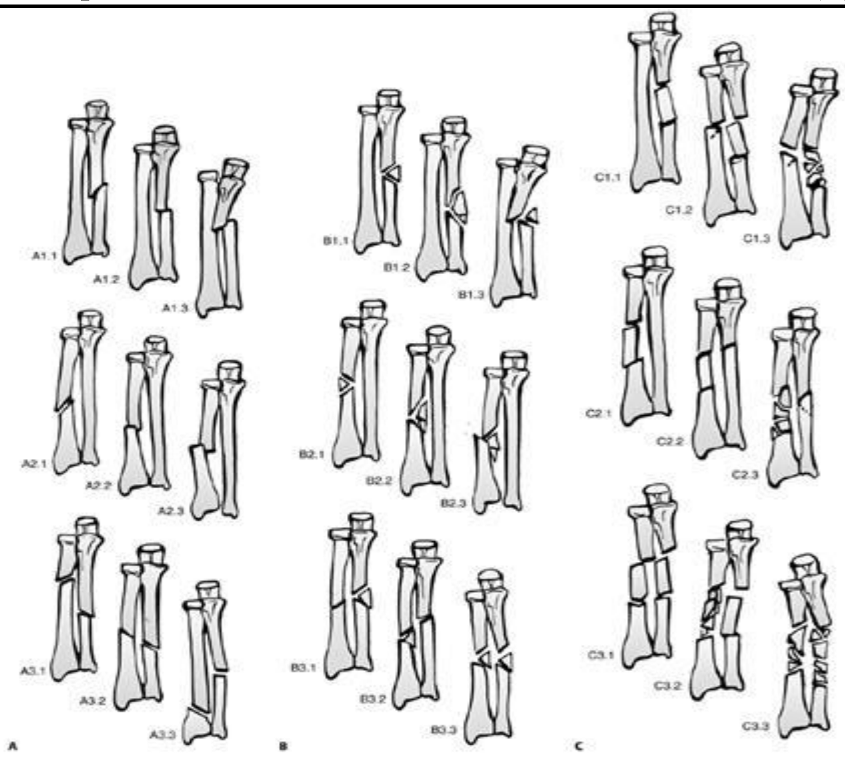

Figure (7) AO classification of both bones forearm fractures **11**

Presentation

- ❖ Symptoms
- ● History of trauma to the forearm
- ● Gross deformity, pain, and swelling
- ● Loss of forearm and hand functions
- ❖ Physical exam
- ● Inspection
- ▪ Open fractures
- ▪ Check for compartment syndrome
- ● Neurovascular exam
- ▪ Assess radial and ulnar pulses
- ▪ Document median, radial and ulnar nerves function
- ● Pain with passive stretch of the digits
- ▪ Alert to impending compartment syndrome

Radiography

Ideas that are suggested

1. Anterior and posterior views of the forearm 2. Extra views 3. An oblique view of the forearm to help define the fracture more precisely 4. Radiographs of the interposterior joints of the wrist and elbow 5. In order to check for related fractures or dislocation, the diagonal head needs to be in line with the capitillum on every image. 11

Treatment

1) **Pediatric**—Closed reduction and splinting followed by casting is an acceptable treatment method in the pediatric population. In children younger than age 9, up to 15° of angulation and 45° of malrotation is acceptable. In children older than age 9, up to 10° of angulation and 30° of malrotation is acceptable. **13**

2) **Adult**—For the adult population, casting does not allow for maintenance of reduction and thus is not an accepted form of treatment. The treatment of choice for an adult both bone forearm fracture is ORIF with plate and screw fixation. **12**

Currently there are several plate options available.

- **Compression plate with a Limited Contact Dynamic Compression plate (LCDC)**—LCDC is recommended to be used for both the radius and ulna with at least six cortices purchased with screws on each side of the fracture **13**. It remains the gold standard for treatment of forearm fractures. **15** as shown in **figure (8)**
- **Locking plates** represent a newer type of fixation. With the advent of locked plates, certain indications have evolved—the main one being osteoporotic bone **12**. Other indications include comminuted fractures or fractures in close proximity to the joints.**16** as shown in **figure (8)**
- **One-third tubular plates**
- **Intramedullary fixation** of forearm fractures is not a standard treatment. It functions as an internal splint only and requires additional bracing or casting. Intramedullary nailing may be of benefit in the treatment of segmental fractures, pathologic fractures, and comminuted fractures, especially due to a gunshot injury. Intramedullary fixation is best used for fractures of the diaphysis and should not be used for injuries near the proximal or distal end of the bone. Intramedullary nail fixation is more commonly used in pediatric forearm fractures.**13**

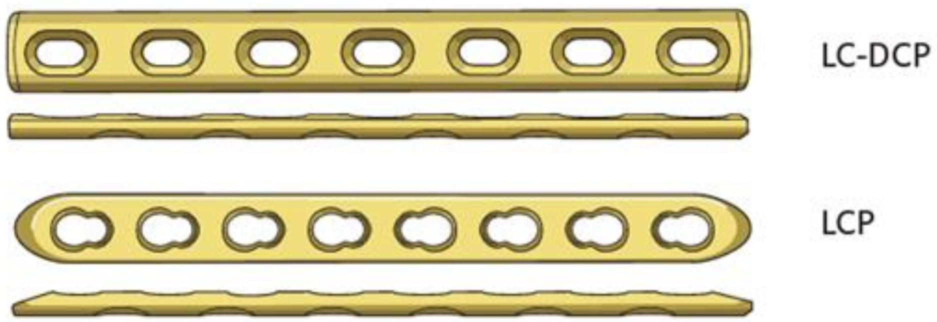

Figure (8) limited contact dynamic compression plate (LCDCP) and locked compression plate (LCP)

Surgical approaches to the forearm

1) ***Anterior (Henry's) approach***

Interval: between the brachioradialis (radial nerve) and pronator teres or FCR distally (median nerve)

Dissection:

Proximally: Isolate and ligate the leash of Henry (radial artery branches) proximally, and strip the

supinator from its insertion subperiosteally; supination of the forearm displaces the PIN ulnarly.
Middle third: Pronate the forearm and incise the insertion of the pronator teres subperiosteally.
Distally: Dissect off the FPL and pronator quadratus.
Risks:
The superficial branch of the radial nerve must be protected (retract laterally) with the brachioradialis. The radial artery is at risk for injury proximally because it courses medial to the biceps tendon and distally with retraction of the brachioradialis. The PIN can be injured during deep dissection of proximal exposure. **3, 14**

2) ***Dorsal (posterior; Thompson's) approach***

Interval: between the ECRB (radial nerve) and extensor digitorum or EPL distally (PIN)
Dissection:
Identify the PIN as it exits the supinator before the forearm is supinated, and reflect the supinator off the anterior surface of the proximal radius.
Distally, retract the APL and EPB to gain access to the middle and distal portions of the radius.
Risks: The PIN must be identified and protected. **3, 14**

3) ***Exposure of the ulna***

Interval: between the extensor carpi ulnaris (PIN) and the FCU (ulnar nerve)
Dissection: Strip muscles from the ulna subperiosteally.
Risks: FCU stripped subperiosteally to protect ulnar nerve and artery. **3, 14**

PATIENTS AND METHODS

2.1. Study Design, Settings and Data Collection Time

This is a prospective randomized comparative study was done from January 2019 to April 2020 in the orthopedic department of Al-Kindy teaching hospital, consists of 25 patients of fractures of both bones of forearm.

Inclusion criteria:-

1) Age between 16 and 55 years.
2) Fresh closed (<10 days old).
3) Intact neurovascular status of the affected extremity.
4) Good function of shoulder, elbow and wrist joints.

Exclusion criteria:-

1) Multiple injured patients.
2) Patients with systemic conditions (Diabetes mellitus, rheumatoid arthritis, Alcoholic).
3) Severely comminuted or open contaminated fractures.
4) Patients with long steroid use (Asthma, some bodybuilders and allergies)

Data Entry and Analysis

Statistical package for social sciences (IBM SPSS v.21) used for data entry and analysis. All data entered day by day to SPSS for explanation of descriptive statistics of study group variables in tables of frequency and percentages. Cross tabulation used to determine the significance of association between independent variables and dependent variable. Chi square and Fischer's exact test used to test association between categorical (qualitative) variables. P value equal or less than 0.05 considered as a cutoff point of statistical significance. Data was presented on tables graphs.

Ethical considerations

1. Informed consents from all patients.

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2. Official approval from the Arab board for health specializations.

Sample and Study Population

Upon admission to the hospital, patients underwent clinical evaluation through history and physical examination. Radiological evaluation was carried out using AP and lateral views X-rays. Putting the damaged forearm in a splint and elevating it were the first steps in managing the injury, along with serial assessments and the administration of suitable analgesics. The patients were then randomly assigned to one of two groups: one that had LCDCP fixation and the other that underwent LCP fixation.

Surgical treatment

There were a total of 25 patients. Twelve patients (7 on the right and 5 on the left) were operated on using 3.5 mm LCP for open reduction and internal fixation in Group A, while thirteen patients (8 on the right and 5 on the left) were operated on using LC-DCP for the same procedure in Group B. The patient was placed in a supine posture while they were under general anesthesia. A well-padded tourniquet was used to secure the upper arm during the operations. Patients were given one dosage of prophylactic antibiotics one hour before to the procedure and were instructed to stop taking them 48 hours following surgery. The surgical site was noted. Sterile drapes were placed after scrubbing the whole upper limb with povidone iodine. Each bone type underwent its own specific incision during the procedures; for example, the ulna always underwent direct posterior approach, the radius underwent dorsal approach for proximal third fractures, and the volar approach for middle and distal thirds. When using LCP fixation, only screws with locking heads were utilized for bridging purposes. However, when fixing the plate for axial compression, two screws without locking heads were used for the proximal and distal fracture fragments. Then, screws with locking heads were used for the remaining holes. Two compression screws were inserted into the proximal and distal fracture fragments as part of the LCDCP fixation procedure, with the other screws left in a neutral position. The screws were left in the neutral position for the bridging purpose. After the tourniquet was removed from both bones that had been fixated, a drain was placed, the closure was done in stages, and a back slab was placed above the elbow to ensure precise homeostasis. At least six months of clinical and radiological follow-up were required. Surgical sutures were removed after 10–14 days, and patients were initially examined once a week for wound examinations. The next step was to visit every three to four weeks until the fractures healed, then every six weeks for three months, and finally every three months. Fracture union, forearm mobility, grip strength, and other consequences were assessed in the results. The criteria established by Anderson et al.17 (table 1) were used to evaluate the union. According to the criteria laid out in table 2 by Anderson et al.17, we were able to evaluate the functional result. Using the criteria outlined by Leung et al.18 (table 3), the reduction quality was evaluated.Table 4 shows the results of the evaluation of the quantity of callus development using the grading method devised by Whelan et al. (19, 20). Surgical site infections (simple, deep, or chronic osteomyelitis), non-union, implant failure, implant fracture, and implant failure were the outcomes measured for the complications. A comparison was made between the two limbs to gauge grip strength. The most recent follow-up values were utilized.

Table (1) the criteria of *Anderson et al for fracture healing.*

Healing <6 months	Union
Healing >6 months	**Delayed union**
Failure of union without secondary intervention	**Non union**

Table (2) the criteria of *Anderson et al* for the functional outcome.

Results	**Union**	**Elbow flexion and extension**	**Pronation and supination**
Excellent	Present	< 10° loss	<25% loss
Satisfactory	Present	< 20° loss	<50% loss
Unsatisfactory	Present	> 20° loss	>50% loss
Failure	Non-union or unresolved chronic osteomyelitis		

Table (3) the criteria of *Leung et al for fracture reduction*

Anatomical reduction	**Precise anatomical alignment with reduction of wedge fragments and fixation with lag screws**
Non-anatomical reduction	**The main fragments are adapted but not compressed, and no precise anatomical reduction of fragments is achieved**

Table (4) scoring charts for calculating the Radiographic Union Score

	Anterior cortex	Posterior cortex	Medial cortex	Lateral cortex	Total
(+) Fracture line, (−) Callus	1	1	1	1	**Minimum 4 Maximum 12**
(+) Fracture line, (+) Callus	2	2	2	2	
(−) Fracture line, (+) Bridging callus	3	3	3	3	

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Figure (9) Pre and post-operative radiographs of LCP fixation

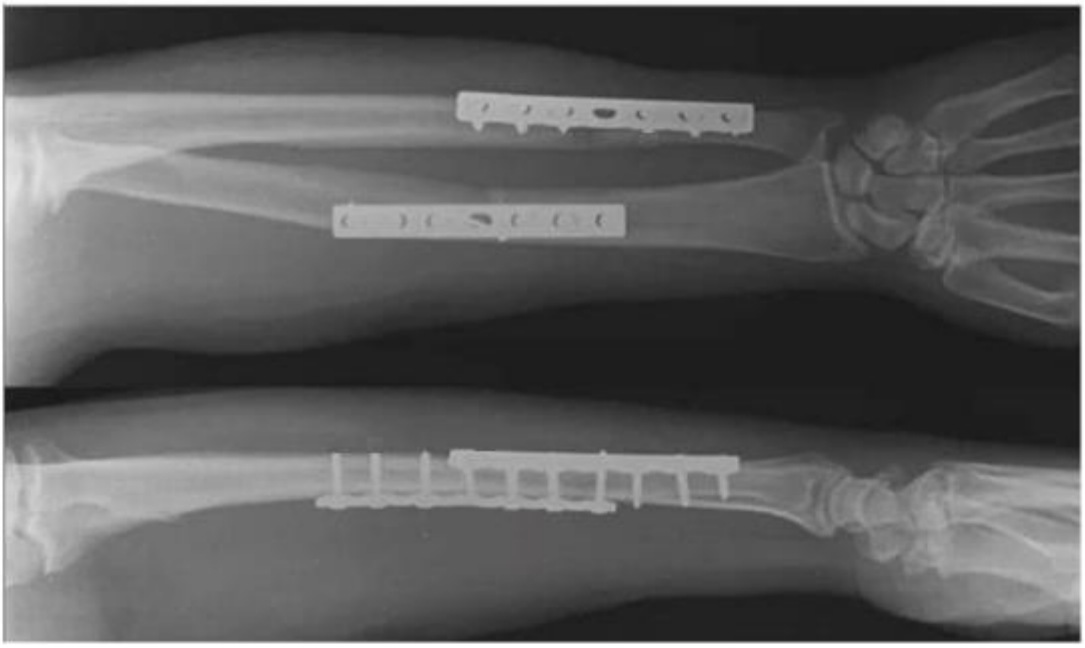

Figure (10) post-operative radiographs of LCDCP fixation

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Figure (11) three months post-operative radiographs of LCP fixation

RESULTS

3.1. Distribution of Study Group by Type of Plate and Anatomical Reduction, Callus Formation, Union, and Functional Outcome.

There were 20 males (80%) and 5 females (20%), male to female ratio 4:1, with an average age of 32 years (range 16–55 years). The distribution of study group by socio-demographic characteristics and smoking history showed in **table (5).**

Table (5) Distribution of Study Groups by Socio-demographic characteristics and smoking Status

	LCP n=12 N (%)	LC- DCP n= 13 N (%)	Total	P-value
Gender:				
Male	10 (83.3)	10 (76.9)	**20**	**0.16**
Female	2 (16.7)	3 (23.1)	**5**	
Age group:				
More than 50	1 (8.3)	2 (15.4)	**3**	
20-50	8(66.6)	8 (61.5)	**16**	**0.29**
Less than 20	3 (25)	3 (23)	**6**	
Smoking Status:				
Smokers	7 (58.3)	9 (69.2)	**16**	**0.32**
Non- smokers	5 (41.7)	4 (30.8)	**9**	

The fractures were classified according to the AO classification system and the number of cases for each class is shown in **table (6).**

Table (6) the distribution of cases according to AO classification

AO type	No. of cases LCP	LC-DCP	Total
A3.1	2	3	5
A3.2	5	5	10
B3.1	1	1	2
B3.2	3	3	6
B3.3	1	1	2
Total	12	13	25

ghteen patients (68%) had a high-energy trauma either road traffic accident (RTA) or fall from height, while the other seven patients (32%) were with history of sport or assault trauma.

The surgical time regarding LCP fixation (range 90–180 minutes, mean 120 minutes) while the time required for LC-DCP (range 80–150 minutes, mean 100 minutes) and this time difference was not significant (*P*=0.73).

Seventy-five percent (*n*=9) in the LCP fixation group and seventy-seven percent (*n*=10) of those in the LC-DCP group were found to have anatomical reduction and the rest had non-anatomical reduction. This difference was not significant (*P*=0.91) as shown in **table (7)** and **figure (12)**.

Table (7) the distribution of cases regarding anatomical and non-anatomical reductions for each fixation type.

Fixation type	LCP N (%)	LC-DCP N (%)	P-value
Anatomical	9 (75%)	10 (77%)	0.91
Non anatomical	3(25%)	3 (23%)	

Figure (12) Anatomical and Non-anatomical reduction percentage for each fixation group

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Seventy five percent (*n*=9) of the fractured forearms in the LCP group healed with radiological findings of callus formation of which; 25% (*n*=3) showed abundant callus formation, 33% (*n*=4) showed moderate callus, 17% (*n*=2) showed minimal callus, and the rest 25% (*n*=3) had no callus formation. In the LC-DCP group; 38% (*n*=5) of the forearms healed with radiological findings of callus formation of which; 8% (*n*=1) showed abundant callus formation, 15% (*n*=2) showed moderate callus, 15% (*n*=2) showed minimal callus and the rest 62% (*n*=8) had no callus formation as shown in **table (8)** and **figure (13)**. So, there was a significant difference presents between both groups regarding callus formation (*P*=0.04).

The functional outcome regarding LCP fixation group was excellent in 9 patients (75%), satisfactory in 2 patients (16.7%), and non satisfactory in one patient (8.3%) without any failure, while the functional outcome of LCDCP fixation group was excellent in 9 patients (69.2%), satisfactory in 3 patients (23.1%), and non satisfactory in one patient (7.7%) also without any failure as shown in **table (8).**

Fixation type	LCP N (%)	LC-DCP N (%)	P-value
Anatomical	9 (75%)	10 (77%)	0.91
Non anatomical	3(25%)	3 (23%)	

Table (8) the difference of callus formation and the functional outcome between the two fixation groups

Variable		LCP n=12 N (%)	LC-DCP n=13 N (%)	P- value
Callus formation	Abundant	3 (25%)	1 (8%)	0.04
	Moderate	4 (33.3%)	2 (15%)	
	Minimal	2 (16.7%)	2 (15%)	
	No	3 (25%)	8 (62%)	
Functional outcome	Excellent	9 (75%)	9 (69.2%)	0.92
	Satisfactory	2 (16.7%)	3 (23.1%)	
	Non - satisfactory	1 (8.3%)	1 (7.7%)	
	Failure	0 (0%)	0 (0%)	

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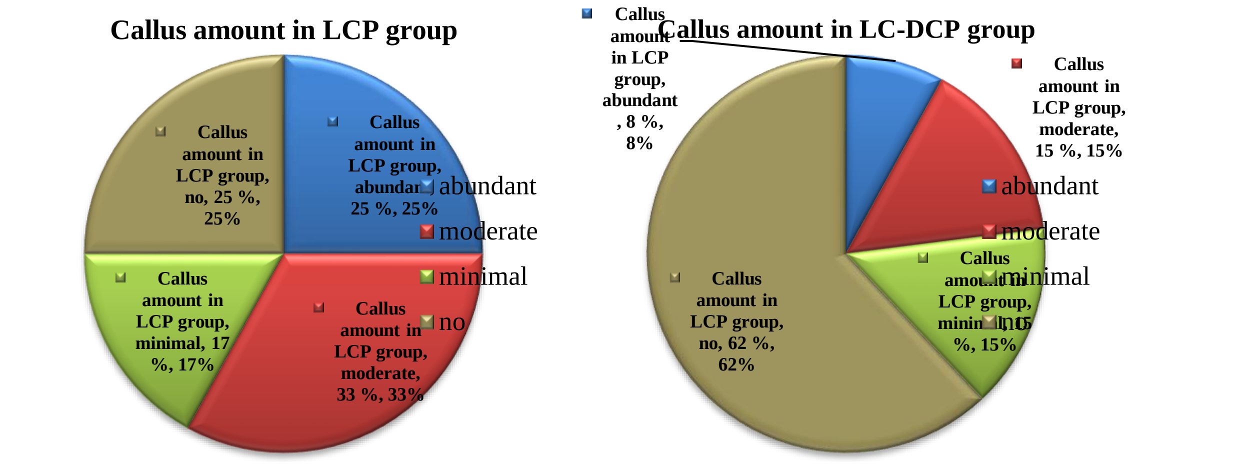

Figure (13) radiological callus amount according to each fixation group

Six out of the nine anatomically reduced forearms (66%) fixed with LCP showed callus formation while three of the ten anatomically reduced forearms (30%) fixed with LC-DCP showed callus formation, as shown in **table (9)**,the difference was not significant (p=0.1).

Table (9) the relationship between the anatomical reduction and the callus formation of each fixation group

Type of fixation Anatomical reduction±callus	LCP N (%)	LC-DCP N (%)	P-value
Anatomical reduction with callus formation	6 (66.6%)	3 (30%)	0.1
Anatomical reduction without callus formation	3 (33.4%)	7 (70%)	
Total	9	10	

Out of the non-anatomically decreased forearms, the LCP group demonstrated radiological evidence of callus development in 100% (3 out of 3 forearms), whereas the LC-DCP group demonstrated 66% (2 out of 3 forearms). In the LCDCP group, the grip strength of the affected side was 90% to 100% of the contralateral side, but in the LCP group, it was 100%. This disparity did not reach statistical significance (P=0.9). Two patients in the LCP group experienced temporary radial nerve palsy after surgery; however, with conservative treatment, their symptoms decreased by the sixth week postoperatively, and they totally recovered by the end of the twelfth week. Following oral antibiotic treatment and regular sterile dressing, two patients in each group experienced a superficial wound infection, which resolved without complications. The patient's fractures healed without complications by the 21st week with moderate callus formation, without requiring additional surgical intervention. However, they did experience a deep surgical site infection and osteomyelitis, which were fully alleviated by the use of third generation cephalosporin antibiotics.

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3.2. Distribution of Study Group by Range of Elbow and Wrist Joint motions and Pronation – Supination Movement.

The mean range of wrist, elbow and pronation – supination range of LCP group is 145.5, 146, and 144.5 respectively, while for LCDCP they are 141.0, 140.8 and 140.7 degree respectively also. There is no statistical significant difference (by independent sample T test), as shown in **table (10)**.

Table (10) comparison between study groups regarding range of elbow joint, wrist joint motions and pronation-supination movement.

Fixation type	Wrist range (Mean ± SD)	Elbow range (Mean ± SD)	Pronation – supination range (Mean ± SD)	p-value
LCP	145.5 ± 1.38	146.0 ± 1.27	144.5 ± 0.79	**0.9**
LC DCP	141.0 ± 0.70	140.8 ± 0.89	140.7 ± 0.83	

DISCUSSION

The patients' ages ranged from 16 to 55 years, with an average age of 32 years (S.D ± 11.55). The results are consistent with those of other studies that found comparable average ages: Saikia et al. 21 (29 years), Sharma S et al. 22 (34 years), and Leung F et al. 18 (35 years).Twenty men made up 80% of each group, with a male to female ratio of 4:1. This follows the same pattern as Saika et al., 21:70, and Manjappa CN et al., 23:25, where men made up 75% of the sample and females 25%. The LCP group had 7 right-sided fractures (58%) and 5 left-forearm fractures (42%), whereas the LCDCP group had 8 right-sided fractures (61.5%) and 5 left-forearm fractures (38.5%). Statistically, there was no discernible change (P>0.05). This result contradicts the findings of Manjappa CN et al. 23, which found that 12 patients (60%) had left forearm involvement and 8 patients (40%) had right forearm fracture. Additionally, this data differs with a research conducted by Singh S et al. 24 which found that the left extremity was involved in 58% of cases and the right extremity in 42%. Five instances (41.6%) of injuries in the LCP group were caused by falls from height, followed by four cases (33.3%) of road traffic accidents, and three cases (25%) of sports-related injuries. Five incidents (38% of the total) included falls from height, four involved road traffic accidents (32% of the total), two involved falls on the hand (15%), and two involved assault (15%) in the LCDCP group. No statistically significant difference (P>0.05) was found between the two sets of data. In a research by Singh S et al. 24 (64% of cases) and Marya KM et al. 25 (88% of cases) involved road traffic accidents (RTAs), respectively. The middle third of the forearm was broken in 13 instances (52%), the upper third in 5 cases (20%), and the distal third in 7 cases (28%). This finding is in line with that of the research by Marya KM et al. 25 that found that 52% of the fractures impacted the middle part of the forearm bones. Half of the patients with proximal third fractures, 15% with lower third fractures, and 60% with middle third diaphyseal fractures were found in the study by Manjappa CN et al. 23. In the LCP group, the average operating time was 120 minutes, ranging from 90 to 180 minutes; in the LC-DCP group, the average operating time was 100 minutes, ranging from 80 to 150 minutes. We could not find a statistically significant difference (P=0.73) in the amount of time the surgery took.

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Compared to LCDCP, where the mean operative duration was 81.94 minutes with a range of 60-100 minutes, LCP had an average operating time of 93.05 minutes with a range of 75-180 minutes in Saikia KC et al. 21. In our study, we found that in the LCP group, moderate callus formation occurred in 4 cases (33%), minimal callus formation in 2 cases (17%), and no callus formation in 3 cases (25%). In contrast, in the LCDCP group, we observed abundant callus formation in 1 case (8%), moderate callus formation in 2 cases (15%), minimum callus formation in 2 cases (15%), and no callus formation in 8 cases (62%). So, although 38% of the LCDCP group saw callus development, 75% of the LCP group did not.A statistical analysis revealed a significant difference (p=0.04). In their study, Saikia et al. 21 found that radiographic results of callus development indicated that 56% of fractures in the LCP fixation group had healed, but only 17% of the forearms in the LC-DCP group had done so. In the group treated with LCDCP, the average duration for forearm fractures to heal was 17 weeks (range 12-24 weeks), whereas in the LCP group it was 14 weeks (range 9-21 weeks). Statistical analysis revealed no statistically significant change (P=0.91). Forearms fused with LCP took an average of 14.16 weeks (range 8-21 weeks) to union in the research by Saikia et al. 21, but those fused with LCDCP took an average of 16.27 weeks (range 10-29 weeks). In their research of diaphyseal forearm bone fractures treated with locking compression plates (LCPs), Sharma S et al. 22 found that the average union time was 12.6 weeks, ranging from 8 to 24 weeks. According to research by Manjappa CN et al. 23 on the surgical treatment of adult forearm bone fractures with LC-DCP, the average duration for union was 17 weeks. The average time it took for a forearm fracture treated with LCP to heal was 20 weeks (range 8-36 weeks), according to research by Leung F et al. 20. The functional outcomes for the nine patients (75% of the total) in the LCP group were excellent, satisfactory, or poor. As for the functional outcomes, nine patients (69% of the total) in the LCDCP group reported outstanding results, three reported adequate results, and one reported bad results. Statistical analysis has shown no discernible difference between the two sets of data. (Pi= 0.922). With no failures, Saikia KC et al. 21 found that 89% of patients had good functional outcomes, 8% had satisfactory outcomes, and 3% had poor outcomes. In their study, Marya KM et al. 25 found that 88% of patients had an outstanding functional outcome, 7% had an acceptable outcome, 4% had an unsatisfactory outcome, and 1% had a failure.

CONCLUSION

While there was no statistically significant difference in the functional outcomes between the two groups, there was a notable difference in the amount of callus formed between the two groups following LCDCP fixation compared to LCP fixation for adult diaphyseal fractures of the forearm's two bones. There was no failure in either group's union rate, which was 100%. Our study's shortcomings include a lack of long-term follow-up and a very small sample size in both groups. From a functional standpoint, we believe that the union rate and functional outcome are both much improved after open reduction and internal fixation using LCP and LCDCP.

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