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A randomized controlled study of dynamic compression plate (DCP) versus limited contact dynamic compression plate (LC-DCP) in treatment of forearm bone fractures in adults (age 18-60 years)

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Abstract
Background and objectives: Fracture of forearm bone are one of the most common injuries seen in day to day practice. The forearm, in combination with the proximal and distal radioulnar joints, allows pronation and supination movements that are important to all of us in the usual activities of daily living. The forearm serves an important role in upper extremity function, facilitating positioning the hand in space, thus helping to provide the upper extremity with its unique mobility. Exacting and decisive management is required after fractures of the shafts of the radius and ulna if function is to be restored.
Methods: A prospective randomized controlled study comprising of 50 cases of Fracture of forearm bone with equal distribution of cases (using randomization list) i.e. 25 cases with Dynamic Compression Plating (DCP) (Group A) and 25 cases with Limited contact dynamic compression plating (LC-DCP) (Group B) was done with patients admitted to Sri Siddhartha Medical College, Hospital & Research Centre, Tumkur from April 2015 and April 2017.
Results: The Limited contact dynamic compression plating of diaphyseal bones produced excellent Results, the advantages being early mobilization, rigid fixation and hence prevention of fracture disease. The only disadvantage is that it is more expensive than the DCP.
Conclusions: The conclusion of our study was that Limited contact dynamic compression plate (LC-DCP) has a definite advantage over Dynamic compression plate (DCP) with respect to time to union and screw placement in comminuted fractures and in case of osteoporotic bone, but the complications, duration of surgery and surgical technique virtually remains unchanged.

Keywords: Fracture of forearm bone, Dynamic compression plating, Limited contact dynamic compression plate

1. Introduction
It is difficult to achieve a satisfactory closed reduction of displaced fractures of the forearm bones, and if achieved, it is hard to maintain, for this reason fractures of both bones or a displaced isolated fracture of the radius and ulna should be treated by open reduction, plate fixation, and cancellous bone grafting whenever there is bone loss. It is essential to regain length, apposition, axial alignment and normal rotational alignment while treating diaphyseal fractures of the radius and the ulna to gain good range of pronation and supination. The chances for the occurrence of malunion and non-union are greater because of the difficulties in reducing and maintaining the reduction of two parallel bones in the presence of the pronating and supinating muscles, which have angulatory as well as rotatory influences [1]. Open reduction and internal fixation with plating is generally accepted as the best method of treatment for displaced diaphyseal fractures of the forearm in the adults [2] The value of compression in obtaining rigid internal fixation had been noted by various authors [3,4,5]. Compression techniques have a lower incidence of non-union and are found to hasten rehabilitation, with less joint stiffness [6-11]. In conventional plating, the actual stability results from the friction between the plate and the bone, which in turn may prevent periosteal perfusion [12, 13]. The biologic plating entails a sufficiently stable fixation of the bone fragments, allowing early mobilization without major disturbance of the vascularization [14].

The limited contact dynamic compression plates (LC-DCP), developed in 1991, was said to reduce the bone-plate contact by approximately 50% to minimise the disruption of periosteal blood vessels beneath the plate. [13] But the LC-DCP still relied on the plate-bone interface for stability [12, 13] and the problem of confluent contact areas was not completely resolved. Later on, the Point Contact Fixator (PC-Fix), which did not have surface contact with the bone but only point contacts, was developed [12]. Leung *et al*. in a prospective, randomized trial comparing the LC-DCP with the PC-Fix in the treatment of forearm fractures concluded that the two implants appeared to be equally effective for the treatment of diaphyseal forearm fractures [12].

The most significant impact on the treatment of forearm fractures was the development of compression plate osteosynthesis. However, it is important to realize that the choice of implant is not the only parameter that governs the outcome. It is important to evaluate the patient & the type of surgery that is involved in the management of these fractures [15] With conventional plating, the screw acts as an anchor, with its axial" force being exploited to press the plate against the bone, this produces large frictional force at the bone plate interface when the construct is loaded, and this force has been shown to cause vascular disturbances, especially in the periosteum.

Methods

The present study was conducted in Department of Orthopedics at Sri Siddhartha medical college, hospital and Research Center Tumkur during the period from April 2015 and April 2017. A total of 50 patients attending the hospital during the study period with closed diaphyseal fracture of both bones forearm aged more than 18 years who were medically fit for surgery were included in the study.

On an average 50 cases were operated for plating of forearm bones in one year. Sample size Was taken as 50 cases with equal distribution of cases (using randomization list) i.e. 25 cases With Dynamic Compression Plating (DCP) (Group A) and 25 cases with Limited contact Dynamic compression plating (LC-DCP) (Group B) was done. Here a prospective Randomized clinical trial was done using the sealed envelope technique. Proximal radius was approached by dorsal Thompson incision and volar Henry approach was used for middle and distal radius. Subcutaneous approach was used for the ulna. A narrow 3.5mm LC- DCP or DCP was used and a minimum of 6 cortices were engaged with screw fixation in each fragment.

Post operatively a crepe bandage was applied over affected forearm and limb elevation given. With the instruction of active finger movement. Drain removed after 24-48 hours and arm Pouch given. Wound inspected on 3-4 days. Antibiotics and analgesics used for initial five Days. Check X-rays in anterioposterior and lateral were obtained. Sutures removed on 10 day and discharged with the advice not to lift any weight or exert the operated forearm.

All the patient followed up at monthly interval for first 3 months and later every six months and evaluation was done based on "Anderson *et al*" scoring system. Movements of elbow, Wrist and forearm were noted clinically and union assessed radiologically.

Aims and objectives

Aim of the study

To provide early and complete functional activity of the upper extremity.

Primary: To Study the efficacy of Dynamic compression plate (DCP) versus

Limited contact dynamic compression plate (LC-DCP) with regards to

Fracture fixation, Implant fixation and Bone reaction.

Secondary: To find out intra operative (per-operative) and postoperative

Complications of the surgery.

Inclusion criteria

1. All diaphyseal fractures of forearm bone.
2. Patients more than 18 years of age
3. Closed fractures

Exclusion Criteria

1. Patients below 18 years of age
2. Open Fractures, segmental Fractures, associated neuro vascular injuries

All patients on admission underwent a thorough clinical examination with regards to site of injury, presence of swelling and effusion in adjacent joints, neurovascular deficits and other associated injuries.

An X-ray in AP and Lateral view with both the elbow and wrist joints were taken. The patients were then given a posterior slab. All patients were given inject able analgesics on arrival and continued on oral analgesics and intravenous antibiotics was given one night prior to the operation and continued for 4 days postoperative. Routine Blood and Urine Investigation were done

Incision

- **Ulna shaft:** Parallel and slightly volar to the subcutaneous crest of the ulna.
- **Radial shaft:** Dorsal Thompson approach and Volar Henry's approach.

Operative procedure

With the patient under suitable anaesthesia, tourniquet was applied to the affected limb in all the patients. Painting and draping of the part done.The ulna was directly approached over the subcutaneous border. The radius was approached depending on the level of fracture. For upper third Thompson's posterior approach was used and for lower third Henry's anterior approach was used. For middle third either of the both was taken.

When either one bone was fracture it was approached directly by any of the above-mentioned approaches. But when both bones were fracture the fracture site was approached one after the other and a trial reduction was done, and then fracture ends were cleaned. Later the periosteum was elevated. The fracture reduction was held with reduction forceps. A plate with at least six holes was chosen, but for spiral and comminuted fractures longer plates with more number of holes was taken.

Next the nearest available hole was drilled on the opposite side of the fracture with the eccentric drill guide with the arrow on the guide pointing towards the fracture. A 3.5 Mm screw of appropriate length was put using the mentioned technique. Using the neutral drill guide, the first screw is applied to the fragment, which forms an obtuse angle with the fracture near the plate. The resulting space between the fracture plane and Plate under surface guides the opposite fragment towards the plate. The arrow of the Neutral drill guide points towards the fracture. 2.5mm drill bit is used for drilling a Hole through both cortices and with depth gauge,

appropriate 3.5mm screw length is Determined, 3.5mm drill tap used before screw insertion [16].
After stable fixation had been achieved, haemostasis was secured meticulously and suction drain was kept, before closing the wound.

Post-Operative management: Postoperative X- ray was taken, intravenous antibiotics was given for 4 days and later oral antibiotics were given till 1 day after suture removal. Analgesics were given for 5 days postoperatively. Posterior above elbow slab given and limb was elevated for 48 hours and was advised active finger movements. The drain was removed after 72 hours. Sutures were removed on 10-13thday. In our study we noted the duration of surgery for fixation of both bones forearm ranged from 60-90 min, with average time of 72 min. The tourniquet time ranged from 50-70 min, with average time of 54 min. Later depending on the fracture pattern and fixation, patient was given above elbow slab and advised to do active shoulder exercises.

Follow-up
All the 50 patients were followed up at 4-6 weeks, 11-14 weeks and 6 months for functional and radiological review. Elbow movements and wrist movements were noted and the union was assessed radio logically and clinically.

Criteria for Evaluation of Radiological and Clinical Results:
Anderson *et al* (1975) criteria were used to evaluate radiological and functional results [3]

Radiological Criteria
A fracture was designated healed radiologically when there was presence of periosteal callus bridging the fracture site or trabaculation extending across it, and when there was obliteration of fracture in rigidly compressed fractures.

Functional results

Results	Union	Flexion/Extension at Elbow Jt.	Supination/ And Pronation
Excellent	Present	< 10° Loss	< 25° Loss
Good	Present	< 20° Loss	< 50° Loss
Fair	Present	> 20° Loss	>50° Loss
Poor	Nonunion	With or Without Loss of Motion	

Results
The observations made on the data collected from 25 cases in Group A and 25 cases in Group B are as follows:

Age Distribution
In our study we had majority of cases (52%) in 20- 30 age group with average of 36 years (18-58) years in Group A and Group B majority of cases (44%) were in 40-50 years with an average of 38.6 years (18-56) years. (Table 1)

Sex Distribution
In both the groups there was equal distribution with Males accounting for around 80% and Females 20%. (Table 2)

Side of Fracture
In both the groups left side was involved in around 40% of cases and right side around 60%. (Table 3)

Mechanism of Injury
In group A RTA's accounted for majority of cases (60%) and group B (76%) RTA and Fall has 36% and 24% each and one case of assault (4%) in group A. (Table 4)

Type of Fracture – AO Classification
In group A there was majority of C type 60% (comminuted) AO type of fractures and in group B 56% were type C (Table 5).

Level of Fracture
Majority of cases (60.32%) in group A were at middle third and in group B it was 64.96 %. (Table 6)

Hospital stay
The average hospital stay was 8- 14 days in group A (56%) and in the group B(64%) (Table 7).
In Group A the average follow up was 12.8 months range (6-20 months)
Group B the average follow up was 13.1 months range (6-18 months)

Criteria for Evaluation of results Radiological and clinical

Determination of union
Using the Criteria of Anderson *et al* [3]

1. Fractures which healed in less than 6 months were classified as unions.
2. Those, which required more than 6 months to unite and had no additional operative procedures, were classified as delayed unions.
3. Those, which failed to unite without other operative procedures, were classified as non-unions.

Functional Results
Using Anderson criteria for radiological union. In group A the average time for radiological union was 8.6 weeks (6- 22 weeks) and in Group B the average time was 6.3 weeks (4- 12 weeks)

Results	Group A No of Cases	%	Group B No of cases	%
Excellent	17	68	20	80
Good	4	16	3	12
Fair	2	8	2	8
Poor	2	8	-	-

From the above study Chi-square value is found to be 0.275 at degree of freedom 1, so p value is more than 0.5 which signifies that there is not much difference in functional results in both the study groups.

Complications
In our present study we had 2 nonunion (8%), 1 superficial infection (4%), 1 loss of movement (4%) and 1 had posterior interosseus nerve palsy (4%) postoperatively in Group A. Bone grafting for nonunion was done, superficial infection was managed by removing the sutures and thorough cleaning was done and the patient with nerve palsy recovered after 4 months of physiotherapy.
In Group B we had 1 nonunion (4%), 1 superficial Infection (4%), 1 posterior interosseus nerve palsy (4%) and 1 radioulnar synostosis (4%) (Table 8)

Discussion

The forearm serves as an important role in upper extremity function, facilitating positioning the hand in space, thus helping to provide the upper extremity with its unique mobility. The competent initial management of diaphyseal fractures of the radius and ulna can prevent many chronically disabling disorders of the forearm.

It is difficult to achieve a satisfactory closed reduction of displaced fractures of the forearm bones, and if achieved, it is hard to maintain. Unsatisfactory results of closed treatment have been reported to range from 35% to 72%. For this reason, open reduction with internal fixation is routine except for undisplaced fractures.

Undisplaced single bone fractures should be treated in a long-arm cast until there is roentgenographic evidence of union or definitive evidence of delayed union.

At a minimum, there must be screws engaging six cortices above and below the fracture site. The use of 3.5 mm plate systems has nearly eliminated the problem of refracture after plate removal. Eight whole plates are used most often. Cancellous bone grafting of these fractures, in addition to plate fixation, should be considered, as the union rate using this method of treatment has been nearly 100%.

The AO formulated four treatment principles that were expected to improve the results of fracture treatment in general and of internal fixation in particular (Muller *et al*) [5]

Determination of union Chapman *et al* [6] included the periosteal callus bridging the fracture site as a radiographic criterion for union, in addition to Muller's criteria. In our study we followed Anderson *et al* (1975) criteria to evaluate the union of fracture i.e. fracture line obliteration and bridging of trabeculae across fracture.

There has been a few clinical study available on comparing DCP (Group A) and LC-DCP (Group B). So in our study we have done comparison between Group A and Group B and other studies of DCP.

In the present study the average age was 36 years (18-58 years) in group A and in Group B it was 38.6 years (18-56 years) compared to Chapman's series where it was 33 years (13-79 years) which was almost the same and was higher compared to H. Dodge's [17] 24 years (13-59) in his study. Average 80% of cases in our study were males and 20% were females as compared to H. Dodge's series which was 89% and 11% respectively. The Right side was involved in around 50% of cases in our study whereas there was 55% involvement of right side in Chapman's series (Table 9)

A total of 86 bones were fixed in 50 patients of which 45 were ulna and 41 were radius. In Group A there were 17 Both Bone (68%), 5 isolated ulna (20%), 2 isolated radius (8%) and 1 Galeazzi (4%) fractures. In Group B there were 19 Both Bone (76%), 4 isolated ulna (16%) and 2 isolated radius (8%) fractures compared to Chapman's [6] series which had 42 both bones 18 radius and 27 ulnas in a total of 129. We had no Monteggia and 1 Galeazzi fractures compared to Chapman's 10 (Table 10)

The average duration of follow up in our study was 13.2 months (6-20 months) which was almost same as Chapman's follow up which was a minimum of 12 months. Naiman [18] it was 18 months (8-36 months). (Table 11)

Using Anderson's *et al* criteria for radiological union. In group A, the Average time for radiological union was 8.6 weeks (6-22 weeks) and In Group B, the average time was 6.3 weeks (4-12 weeks) respectively. As compared to Anderson's own union rate of 7.4 weeks. Group B required lesser time for union than others as LC-DCP treated group indicating the more rigid fixation and limited bone to plate contact and this would lead to protection of periosteal blood supply. Thus leading to early union and may be the reason for better results in group B. (Table 12)

Further using Anderson's *et al* criteria for functional results we had 68% Excellent, 16% Good, 8% Fair and 8% Poor results in Group A and 80% Excellent, 12% Good, and 8% Fair results in Group B Compared to Anderson's 59% Excellent, 31% Good, 7% Fair and 3% Poor and Chapman's 83%, 8%, 7% and 2% respectively. Here Group B had best results compared to others. (Table 13)

Anderson *et al* in their study have not found any evidence of damage to the bone from compression produced by the ASIF technique. On the other hand they found no evidence of stimulation of osteogenesis. By compression they believe that major advantages of the ASIF technique are as follows:

1) Compression increases the rigidity of fracture stabilization by impacting the bone ends.
2) The developing or periosteal blood supply is protected by rigid fixation in case of LC-DCP.

Conclusion

Fractures of both bones of forearm in adults are commoner in second and third decade of life.

Males predominant in the high incidence of fractures due to manual working and

Outdoor activities.

- The 3.5mm LC-DCP, properly applied, is an excellent method for internal fixation of Fractures of the forearm bone.
- Use of tourniquet, separate incisions for radius and ulna and preservation of the natural Curves of radius will lesser the rate of complications.
- These fractures have to be fixed as early as possible and it is important to achieve Anatomical reduction and stable internal fixation for excellent functional outcome.

We observed that the fracture gap was obliterated or greatly diminished by compression plates.

The Limited contact dynamic compression plating of diaphyseal bones produced excellent results, the advantages being early mobilization, early union and hence prevention of fracture disease. The only disadvantage is that it is more expensive than the DCP.

The conclusion of our study was that Limited contact dynamic compression plate (LC-DCP) has a definite advantage over Dynamic compression plating (DCP) with respect to time to union and screw placement in comminuted fractures, and in osteoporotic bone but the complications, duration of surgery and surgical technique virtually remains unchanged.

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Declarations

Funding: none

Conflict of interest: none

Ethical approval: Approved by ethical committee.

Table 1

b	Group A No of Cases	%	Group B No of Cases	%
<20	1	4	3	12
21-30	13	52	5	20
31-40	6	24	2	8
41-50	3	12	11	44
51-60	2	8	4	16
	25	100	25	100

Table 2

Sex	Group A No of Cases	%	Group B No of Cases	%
Male	20	80	18	72
Female	5	20	7	28
	25	100	25	100

Table 3

Side of fracture	Group A No of Cases	%	Group B No of Cases	%
Right	15	60	16	64
Left	10	40	9	36
	25	100	25	100

Table 4

Mechanism of injury	Group A No of Cases	%	Group B No of Cases	%
RTA	15	60	19	76
Fall	9	36	6	24
Assault	1	4	-	-
	25	100	25	100

Table 5

Type of Fracture	Group A No of cases	%	Group B No of cases	%
A1	-	-	-	-
A2	1	4	-	-
A3	1	4	-	-
B1	4	16	-	-
B2	-	-	-	-
B3	4	16	6	24
C1	-	-	3	12
C2	-	-	2	8
C3	15	60	14	56
	25	100	25	100

Table 6

Level of fracture	Group A No of Bones	%	Group B No of Bones	%
U/3rd	10	23.2	10	23.2
M/3rd	26	60.32	28	64.96
L/3rd	6	13.92	5	11.6
Segmental	1	2.32	-	-
	43	99.76	43	99.76

Table 7

No of Days	Group A No of cases	%	Group B No of cases	%
0-7	2	8	3	12
8-14	14	56	16	64
15-21	8	32	5	20
>21	1	4	1	4
	25	100	25	100

Table 8

Complication	Group A No of Cases	%	Group B No of cases	%
Non union	2	8	1	4
Superficial infection	1	4	1	4
Loss of Movement	1	4	-	-
Post. Int.N.Palsy	1	4	1	4
Synostosis	-	-	1	4
	5	20	4	16

Table 9: Age group (in years) and Sex incidence (%)

Series	Minimum age	Maximum age	Average	males	Females
M.W. CHAPMAN	13	79	33	78	22
Group A	18	58	36	80	20
Group B	18	56	38.6	72	28
H.Dodge's [17]	13	59	24	89	11

Table 10: Bones Involved (No of Cases)

Series	Fracture BB	Fracture Radius	Fracture Ulna	Total
Group A	17	2	5	41
Group B	19	2	4	44
Chapman [6]	42	18	27	129

Table 11: Duration of follow up (months)

Series	Range	Average
Group A	6-20	12.8
Group B	6-18	13.1
Chapman[6]	6-48	12
Naiman[18]	8-36	18

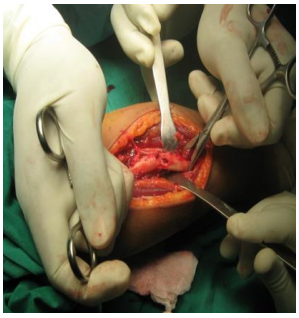
Table 12: radiological union (Weeks)

Series	Union	Range
Group A	8.6	6-22
Group B	6.3	4-12
Anderson[4]	7.4	5-10

Table 13: Functional results (%)

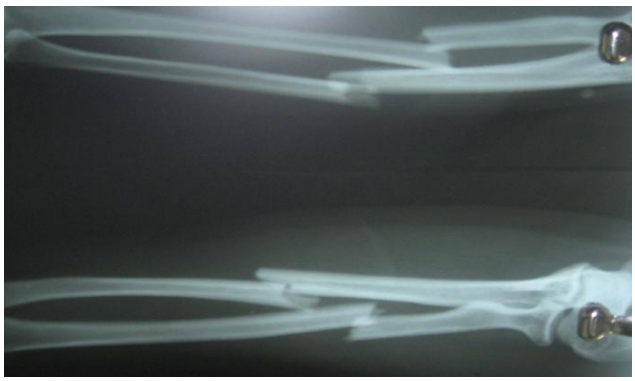
Series	Excellent	Good	Fair	Poor
Group A	68	16	8	8
Group B	80	12	8	-
Anderson[3]	59	31	7	3
Chapman[6]	83	8	7	2

Intraoperative photos

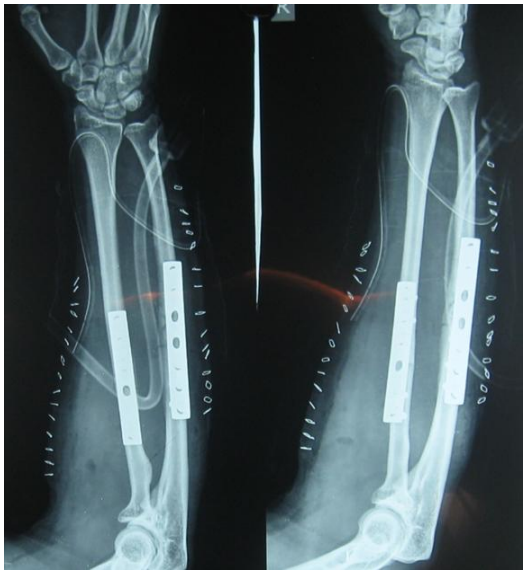



DCP (group A)

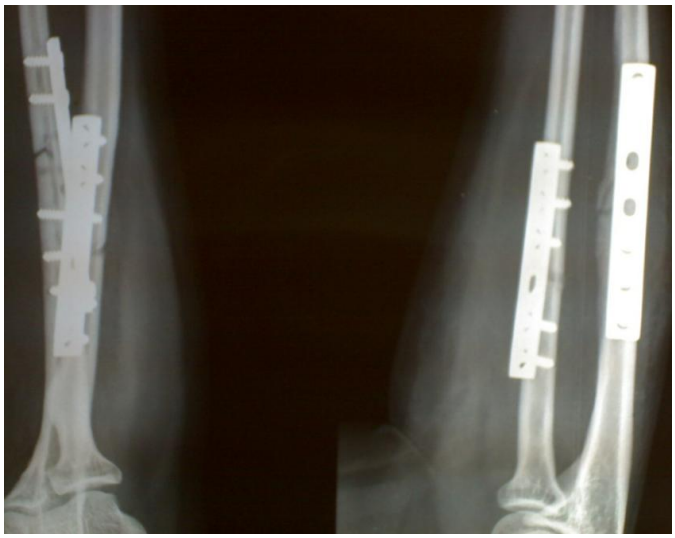
Case 6 Preoperative x-ray



Postoperative x-ray



Follow up x-ray



Clinical photographs

Full Extension

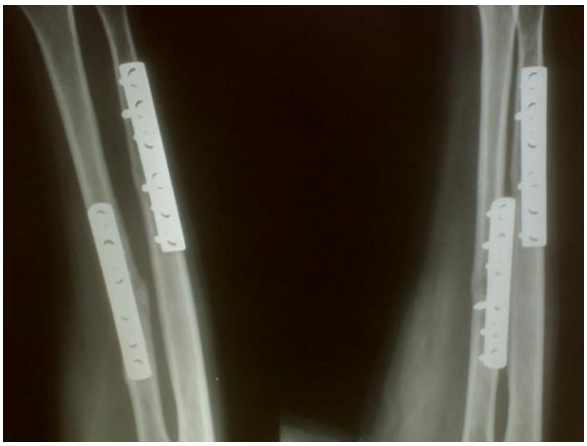
FULL SUPINATION

Full PRONATION

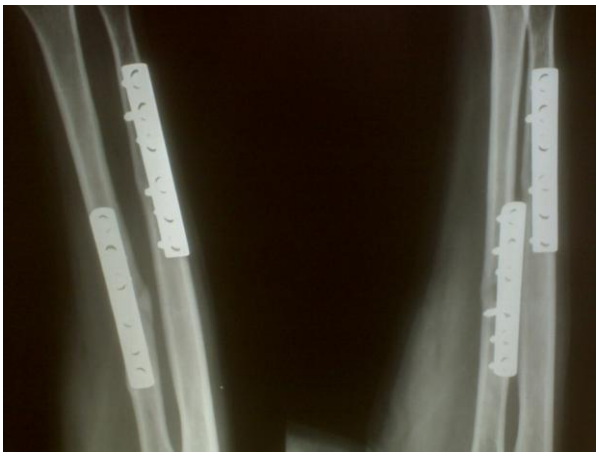
Full Flexion

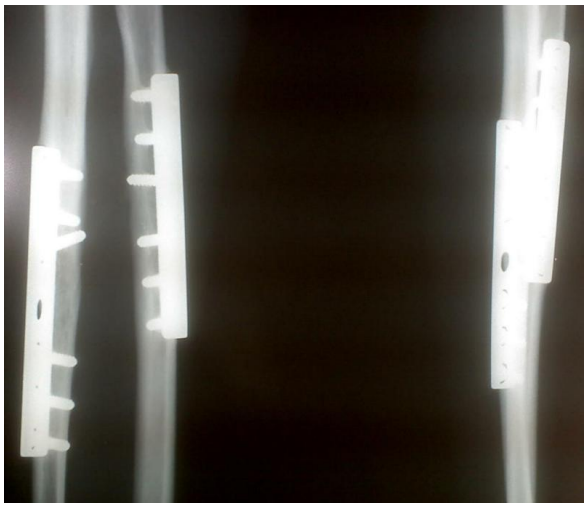
Case 13

Preoperative x-ray



At 8 weeks and final follow up x-ray

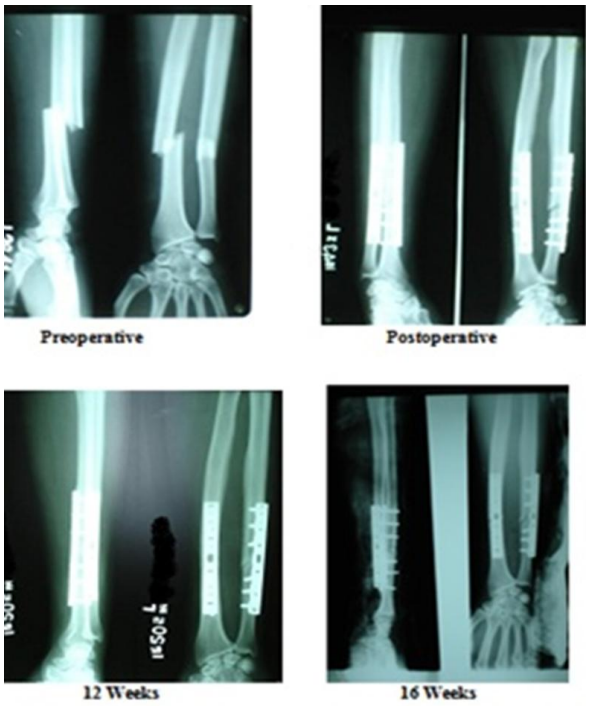




LC-DCP (groupB)

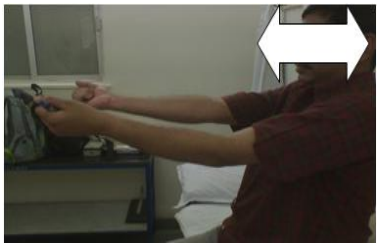
Case 15: a. preoperative, b. post-operative and c. final follow up x-ray

Case 28.



Clinical photographs

Full flexion

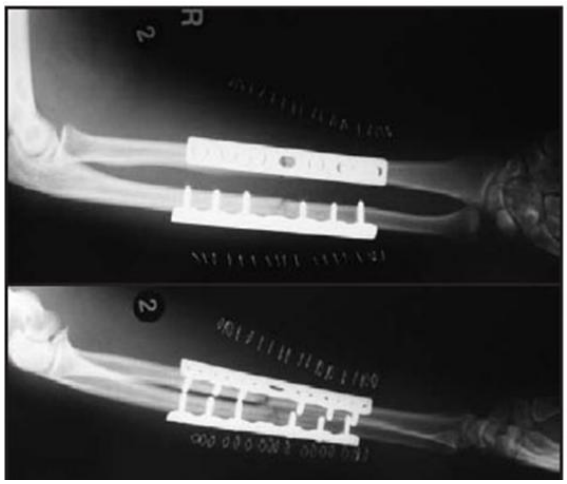


Full extension

Full supination

Full pronation

Case 2



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