"A RANDOMIZED CONTROLLED STUDY OF DYNAMIC COMPRESSION PLATING (DCP) VERSUS LOCKING COMPRESSION PLATING (LCP) IN TREATMENT OF FOREARM BONE FRACTURES IN ADULTS (Age 18-60 YEARS)"

By

DR. RAVI.K.B
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Dissertation

SUBMITTED TO THE KLE UNIVERSITY, BELGAUM IN PARTIAL FULFILLMENT OF THE REGULATIONS FOR THE AWARD OF THE DEGREE OF

M.S(ORTHOPAEDICS)

Under the guidance of

DR. KIRAN. S. PATIL MBBS, DA(BOM), D.ORTHO, M.S(ORTHO)
Professor and Unit Head

DEPARTMENT OF ORTHOPAEDICS

JAWAHARLAL NEHRU MEDICAL COLLEGE,
BELGAUM-590010, KARNATAKA

MAY –2011.

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Date:

Place: Belgaum.

Signature of the Guide

Dr. KIRAN. S. PATIL

MBBS,DA(BOM),D.ORTHO,M.S(ORTHO)
Professor and Unit head

Department of Orthopaedics,

J. N. Medical College,

Nehru Nagar, Belgaum-590010.

KLE UNIVERSITY, BELGAUM.

KARNATAKA.

ENDORSEMENT BY THE HOD

This is to certify that the dissertation entitled **"**A RANDOMIZED CONTROLLED STUDY OF DYNAMIC COMPRESSION PLATING (DCP) VERSUS LOCKING COMPRESSION PLATING (LCP) IN TREATMENT OF FOREARM BONE FRACTURES IN ADULTS (AGE 18-60 YEARS)**"** is a bonafide and genuine research work done by **Dr. RAVI. K.B ,** under the guidance of **Dr. KIRAN .S. PATIL,** MBBS,DA(BOM),D.ORTHO,M.S(ORTHO) Professor, Department of Orthopaedics, JAWAHARLAL NEHRU MEDICAL COLLEGE, Nehru Nagar, BELGAUM.

Date:

Place: Belgaum

Signature & seal of the H O D

Dr. V.G. MURAKIBHAVI.

M.S(ortho),D (ortho), AO Fellow.

Professor and Head

Department of Orthopaedics ,

J.N.M.C, NEHRU NAGAR, BELGAUM.

KLE UNIVERSITY, BELGAUM.

KARNATAKA.

ENDORSEMENT BY THE PRINCIPAL/HEAD OF THE INSTITUTION

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Signature & seal of the Principal

Date :

DR. V.D . PATIL.MD, DCH.

Place- Belgaum

Principal,

Jawaharlal Nehru medical

College, Nehru Nagar, Belgaum.

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I am thankful to PROF. DR. V.D PATIL. PRINCIPAL, J.N.M.C. BELGAUM. I dedicate this dissertation to my FAMILY MEMBERS, and express my thanks to my COLLEGUES for their cooperation and constant encouragement during the preparation of this dissertation work. I thank one and all, who directly or indirectly have helped me to complete the above study.

I bow my head in respect before **God** the almighty.

Date:

Place: Belgaum. **Dr. RAVI. K.B**

LIST OF ABBREVIATIONS USED

AO	-	Arbeitsgemeinschaft fur Osteosynthesefragen
A-P	-	Anteroposterior
ASIF	-	Association for the Study of Internal Fixation
DCP	-	Dynamic compression plate
Ed	-	Edition
JBJS	-	The journal of bone and joint surgery
LAT	-	Lateral
LCP	-	Locking compression plate
M	-	Muscle
MFA	-	Musculo skeletal functional attachment
MM	-	Millimeter
N	-	Nerve
ORIF	-	Open reduction and internal fixation
Vol	-	Volume

ABSTRACT

BACKGROUND and OBJECTIVES

KLE DR.PRABHAKAR KORE HOSPITAL and MRC, BELGAUM being located in a urban area, deals with lot number of polytrauma and fractures of the forearm bones. Fractures of the forearm bones may result in severe loss of function unless adequately treated. Severe loss of function may result even though adequate healing of the fracture occurs. To study the principles of dynamic and locking compression plate. To assess the functional outcome of patients with reference to rate of fracture union and its complications. To study follow-up and restoration of function of the forearm.

METHODS

On an average 50 cases were operated for plating of forearm bones in one year. Sample size was taken as 40 with equal distribution of cases (using randomization list) i.e. 20 cases with dynamic compression plating (DCP) (Group A) and 20 cases with locking compression plating (LCP) (Group B). Here prospective randomized clinical trial was done using the sealed envelope technique .

A total of 72 bones were fixed in 40 patients of which 37 were ulna and 35 were radius. In Group A there were 15 both bone (75%), 3 isolated ulna (15%), 1 isolated radius (5%) and 1 galeazzi (5%) fracture. In Group B there were 17 both bone (85%), 2 isolated ulna (10%) and 1 isolated radius (5%) fractures.

All the 40 patients were followed up at 4-6 weeks, 11-14 weeks and 6 months for functional and radiological review.

RESULTS

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).

Using the criteria of Anderson et al [20](1975) the results were graded .

Using the above criteria for radiological union. In groupA the average time for radiological union was 9.1 weeks (6- 22 weeks) and in Group B the average time was 6.4 weeks (4- 12 weeks).

Further using Anderson's et al criteria for functional results we had 75% excellent, 10% good, 10% fair and 5% poor results in Group A and 90% excellent, 5% good and 5% fair results in Group B.

CONCLUSION

The locking 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 is that locking compression plate (LCP) has a definite advantage over dynamic compression plating (DCP) with respect to time to union and screw placement in comminuted fractures, but the complications, duration of surgery and surgical technique virtually remains unchanged.

KEY WORDS

Dynamic compression plate, Locking compression plate, Both bone forearm fracture.

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INTRODUCTION

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. Many chronically disabling disorders of the forearm can be prevented by the competent initial management of diaphyseal fractures of the radius and/or ulna.

The fracture of the shaft of the ulna with associated dislocation of the radial head was first described by Monteggia in 1814 and has been known as the monteggia fracture since then. The single bone fracture of the ulna without dislocation of the radial head is often called a nightstick fracture, an obvious reference to one of the mechanism of injury. The single bone fracture of the radius in the distal third associated with dislocation of the radioulnar joint has several eponyms. Galeazzi, of italy, called attention to this treacherous injury in 1934 and since then it has been referred to as galeazzi's fracture.

Fracture of the forearm bones may result in severe loss of function unless adequately treated. Severe loss of function may result even though adequate healing of the fracture occurs. Hence a proper method of treatment is necessary to

get back stability as well as normal range of function. 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 38% to 74%. 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.

Fractures of both bones or a displaced isolated fracture of the radius or ulna should be treated by open reduction, plate fixation and cancellous bone grafting whenever there is bone loss. This treatment is carried out as a semi-elective procedure as soon as the patient's condition warrants, reduction is easiest when the fracture is treated within the first 48 hours. AO (Arbeitsgemeinschaft fur Osteosynthesefragen) / Association for the study of internal fixation (ASIF), dynamic and locking compression plate provides more secure fixation without cast protection. It produces sufficiently rigid fixation, impaction and compression of the fracture site. It can be inserted through a smaller incision than the standard plate because no external compression device is required.

The dynamic compression plate (DCP) first described by Bagby and Denham and more recently developed by the AO school has an intrinsic compression device making extensive dissection unnecessary. The plate depends upon the obliquity of cylindrical screw holes for compression which is produced as the screws are driven home. The most effective method of producing rigid internal fixation is by the use of compression plates developed by the AO school in Switzerland. The authors concluded that the use of ASIF compression plates for

acute diaphyseal fractures of the forearm is a very successful method of obtaining union and restoring optimum functional use of the extremity.

The recently developed ASIF compression plating apparatus seemed to satisfy the basic objectives of internal fixation namely:

(1) Anatomical reduction,

(2) Preservation of vascularity ,

(3) Mechanically stable fixation and

(4) Rapid mobilization of the joints in proximity (early active pain-free mobilization of muscles and joints adjacent to the fracture, prevents the development of fracture disease). 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 or ulna should be treated by open reduction, plate fixation and cancellous bone grafting whenever there is bone loss.

There have been only a few studies till date in review of literature comparing both DCP and LCP. Considering the above aims and objectives, the present study was undertaken in a series 40 cases to analyze the comparative study of dynamic compression plating (DCP) i. e Group A and locking compression plating (LCP) i. e Group B in forearm bone fractures.

The patients were evaluated both clinically and radiologically using Anderson et al criteria. The duration of follow up was 12.8 months (6-20 months) for Group A and 13.1 months (6-18 months) for Group B. The average duration of fracture union was 9.1 weeks (6-22 weeks) and 6.4 weeks (4-12 weeks) respectively.

The locking 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.

The conclusion of our study is that locking compression plate (LCP) has a definite advantage over dynamic compression plating (DCP) with respect to time to union and screw placement in comminuted fractures, but the complications, duration of surgery and surgical technique virtually remains unchanged.

AIMS AND OBJECTIVES OF THE STUDY

Primary:

To study the efficacy of dynamic compression plate (DCP) versus locking compression plate (LCP) with regards to fracture fixation, Implant fixation and bone reaction.

Secondary:

To find out intra operative (per-operative) and postoperative complications of the surgery.

RESULTS

In a study of 40 cases of forearm bone fractures, 20 (Group A) were treated with DCP and 20 (Group B) were treated with LCP.

All the 40 patients were followed up at 4-6 weeks , 11-14 weeks and 6 months for functional and radiological review.

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.

Radiological Criteria:

Using the criteria of Anderson et al (1975). A fracture was considered healed radiologically when there was presence of Periosteal callus bridging the fracture site or when there was obliteration of fracture gap , in rigidly compressed fractures.

Determination of union:

Using the Criteria of Anderson et al [20]

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 another operative procedures were classified as non-unions.

Functional Results:

Using the criteria of Anderson et al [20](1975) the results were graded as

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	

Using the above criteria for radiological union. In group A the average time for radiological union was 9.1 weeks (6- 22 weeks) and in Group B the average time was 6.4 weeks (4- 12 weeks).

RESULTS	Group A No of Cases	%	Group B No of cases	%
EXCELLENT	15	75	18	90
GOOD	2	10	1	5
FAIR	2	10	1	5
POOR	1	5	-	-

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:

COMPLICATION	Group A No of Cases	%	Group B No of cases	%
Non union	2	10	-	-
Superficial infection	1	5	1	5
Loss of Movement	1	5	-	-
Post. Int.N.Palsy	1	5	1	5
Synostosis	-	-	1	5
	5	25	3	15

1) Non union:- there were 2 non-unions in Group A with overall rate of 10%. The non-union was due to type of fracture. In the first case it was type C3 comminuted fracture according to the AO classification, was fixed with 6 holed plate for both radius and ulna. After 6 months of radiological review, the fracture did not show signs of union. So after 8 months bone grafting was done and union was attained at 4 months. In the second case there was distal radius fracture, the lower fracture was fixed with T-plate. The lower fracture did not show signs of union radiologically after 8 months. So bone grafting was done and after 3 months fracture showed signs of union.

2) Superficial Infection:- there was 1 superficial infection both in group A and group B, each with overall rate of 10%. In group A one case had mild superficial infection for which 2 sutures were cut off on 5^{th} day and after controlling the infection on

appropriate antibiotic cover, the wound was secondarily closed on 17th day. The fracture healed at 10th week radiologically and had excellent result functionally. In Group B, there was a similar problem and treated amicably under antibiotic cover and had radiological union at 7 weeks and had excellent functional results.

3) Posterior Interosseous Nerve Palsy:- two patients had isolated posterior interosseous nerve palsy in both group A and group B respectively, following brachial block or secondary to traction while reducing. The patients had weak wrist extension and had weak abduction of thumb and weak metacarpophalangeal extension. Both the patients improved after physiotherapy after 4 months and had more than 50% return of function.

4)Loss of Movement:- it accounted for 5% in 1 case of group A. The patient had loss of more than 30˚ flexion-extension and more than 50˚ pronation-supination due to prolonged immobilization by the patient himself.

5)Radioulnar Synostosis:- one patient in group B had Synostosis due to fracture comminution, was detected on radiologically and he had restriction of pronation-supination movements. He was operated after 6 weeks and had excellent result at 6 months functionally.

REVIEW OF LITERATURE

The treatment of forearm fractures was based on the correction of clinical deformity followed by the application of two short wooden splints with a firm pad to preserve the interosseous space with the forearm in midpronation.

Materials and equipment

A. Plaster: Larry D. Iversen and Marc F.Swiontkowski (1994) [1] plaster bandages and splints are made by impregnating crinoline with plaster of Paris – ([Ca SO4]2H2O). When this material is dipped into water, the powdery plaster of Paris is transformed into a solid crystalline form of gypsum and heat is given off. Anhydrous calcium sulfate, hydrated calcium sulfate, plaster of Paris gypsum. The amount of heat given off is determined by the amount of plaster applied and the temperature of the water. The more plaster and the hotter the water, the more heat is generated. The interlocking of the crystals formed is essential to the strength and rigidity of the cast. Motion during the critical setting period interferes with this interlocking process and reduces the ultimate strength by as much as 77%. The interlocking of crystals (the critical setting period) begins when the plaster reaches the thick creamy stage, becomes a little rubbery and starts losing its wet, shiny appearance. Cast drying occurs by the evaporation of the water not required for crystallization. The evaporation from the cast surface is influenced by air temperature, humidity and circulation about the cast. Thick casts take longer to dry than thin ones. Strength increases as drying occurs.

B. Principles. Although plaster of pairs has been used extensively in the treatment of fractures for well over 100 years, there is no unanimity of opinion as to the best technique for application. It can be safely concluded that even the tightest of skintight casts allows some motion at the fracture site, whereas a loosely fitted, well-padded cast with proper three-point fixation can provide satisfactory immobilization. Three points of force are produced by the operator, who molds the cast firmly against the proximal and distal portions of the extremity (two of the points) and locates the third point directly opposite the apex of the cast. Periosteal or other soft tissue attachments usually are required on the convex side of the cast to provide stability. In this way, a curved cast can provide straight alignment of the extremity within it.

Patrick. J. (1946) [2] pointed out that when fractures of both bones of the forearm were perfectly aligned in both anteroposterior and lateral radiological views, the degree of rotation must ipso-facto be correct. In practice this corresponds to the positions advocated by magnason. Patrick also considered that the restriction of motion in these fractures was due to callus or fibrous tissue in the interosseous space, especially from ulna side resulting in shortening and fixation of the interosseous membrane.

MW Chapman, JE Gordon and AG Zissimos (1989) [3] a retrospective study was done of eighty seven patients who had 129 diaphyseal fractures of either the radius or the ulna or both and who were treated with fixation using an AO dynamic compression plate. Open fractures were internally fixed primarily and both comminuted and open fractures routinely had bone-grafting. Ninety-eight percent of the fractures united and 92 percent of the patients achieved an excellent or satisfactory functional

result. The rate of infection was 2.3 percent. Refracture occurred after removal of a 4.5-millimeter dynamic compression plate in two patients, but there were no refracture after removal of a 3.5 millimeter plate. The 3.5-millimeter plate systems gave excellent results in patients who had a fracture forearm and it minimized the risk of refracture.

Hidaka and Gustilo (1984) [4] reported an alarming incidence of refracture following compression plate removal. This is because of weakening of the cortex beneath a rigid plate due to greater stress shielding. It may become thin, atrophic and almost cancellous in character. Extensive soft tissue stripping followed by avascular necrosis and revascularisation may further weaken the cortex.

Ramon B. Gustilo et al (1976) [5] drew the following conclusions regarding open fractures with retrospective and prospective analysis of 1025 fractures.

Perren. S.M. (1979) [6] utilized interfragmentary compression to achieve rigid immobilization of osteotomies of tibia in sheep's. The plates which were used to secure this axial compression were fitted with strain gauges. The amount of compression was checked daily. He demonstrated that in the presence of a stable compression, fixation of a cortex, the compression decayed slowly. By the end of two months, it was reduced to 50%. Control group also showed a similar decay. He was able to demonstrate that the slow decay of compression was not due to shortening of the fragments and resorption but due to haversian modeling.

Sarmiento Augusto and Cooper JS et al (1975)[7] advocated functional bracing for the fractures of forearm. After the initial reduction and plaster cast for about 2 weeks, the brace was applied. This brace is made up of orthoplast with a supracondylar extension, which allowed 100 degree of flexion and prevented supination and pronation but not restricting the wrist movements. It appears that firmly compressed soft tissues maintain fracture stability by a hydraulic effect, which is augmented by the supportive action of interosseous membrane.

Sage (1957)[8]}analyzed a long series of forearm fractures treated with variety of medullary fixation devices. Based on the results from this series and the information obtained from the study of radii dissected from cadavers, sage in 1959 designed a triangular nail with prebent curves for the radius and a straight triangular nail for the ulna. He reported nonunion in only 6.2 percent of cases. Some 15 Swiss general and orthopedic surgeons (1958) met and discussed the causes of poor results obtained with non-operative and operative methods of fracture treatment in their country. This nucleus later developed into a group called ASIF (Association for the study of internal fixation) or AO (Arbeits gemein Sehaft fur Osteosynthese fragen).

Smith J.E.M. (1959) [9] felt that certain long oblique fractures could be fixed with two screws. He also felt satisfactory intramedullary fixation could be achieved by using prebent diamond shaped nails.

N. J. Henderson et al (1982) [10] analyzed the management of complex forearm fractures. They emphasized early and thorough wound debridement, thorough irrigation and delayed closure in all open fractures.

Douglas E. Garland et al (1983) [11] analyzed 47 forearm fractures in 661 head injured adults. Multiple injuries were common. They found no nonunion and one delayed union. In 20% traumatic heterotrophic ossification developed at the elbow. 24% demonstrated calcification in the interosseous membrane with myositis in 18%. High rate of union was accounted to delayed surgery. Their review failed to demonstrate the association between head injury and increasing the rate of union.

Maurice E. Muller et al (1990) [12] who had spent sometime with danis and was impressed by his compression principle in fixation of fractures, the avoidance of external immobilization and the early pain free active mobilization of the injured extremity. They found that the more accurately a fracture is aligned, the less demand there will be for callus. Four principles were accepted as "Working hypothesis"

1) Anatomical reduction

2) Rigid internal fixation

3) Atraumatic technique on soft tissue as well as on the bone.

4) Early pain free active mobilization during the first ten postoperative day. According to AO "**Life is movement and movement is life"** should be the guiding principle of fracture care. A satisfactory internal fixation is achieved only when

external splinting is superfluous and when full active pain free mobilization of muscles and joints is possible.

Goyal S and Iraqi et al (1997) [13] it is difficult to achieve and maintain closed reduction after diaphyseal fracture of forearm bones in adults. They have treated two groups of 50 patients each by narrow DCO and SFS'DCP. Fractures were commonly seen in middle 1/3rd of forearm. They used narrow DCP plate commonly with 6 holes, or SFS'DCP plate having 8 holes for fixation of these fractures. It was found that the operative wound, Periosteal stripping and operation time were less with SFS'DCP, though both these provided good anatomical alignment in both the groups, we observed that following SFS'DCP fixation, functional results were excellent in 86 percent of cases as compared to 80 percent after narrow DCP fixation. Average time to union after narrow DCP and SFS'DCP was 13.36 weeks and 12.80 weeks.

Fatti John F and Mosher (1986) [14] presented in annual complications of fracture of both bones of forearm in a child, a very dense mature scar tissue in the interosseous space.

Ghazi M. Rayan et al (1986) [15] reported entrapment of flexor digitorum profundus in the ulna cortical defect (in fracture both bones of forearm). They opine that this complication can be avoided by achieving anatomical reduction of the both bones at the time of manipulation and by careful examination for active and passive range of motion of all digital joints with wrist in extension.

Emil H. Schemitsch et al (1992) [16] advocated on restoration of the normal radial bow, which was related to the functional outcome.

Charnley. J (1961) [17] has stated, "If a fracture slips in a well applied plaster, then the fracture was mechanically unsuitable for treatment by plaster and another mechanical principle should have been chosen." Another method for providing immobilization by plaster is based on hydraulics. Fractures of the tibia do not shorten significantly when placed in a "total contact" cast. The leg is a cylinder containing mostly fluid and when this water column is encased.

Watson-Jones (1982) [18] said "Internal fixation is nothing more than a bone suture", stressing the importance of immobilization after internal fixation. He said, early mobilization as an advantage of internal fixation is an over emphasis. Finger and shoulder exercises should be encouraged right from the start. He condemned the idea "Internal fixation of the fractures of the forearm with metal can allow unrestricted activities", probably rightly as the internal fixation devices used in those days did not give rigidity or compression.

Eggers GWN (1948) [19] with the unacceptable results of closed methods and with the less than excellent results of a variety of intramedullary appliances, numerous investigators, including eggers, Burwell ,charnley, and others sought more rigid fixation by means of plates and screws.

Anderson LD and Sisk TD et al (1975) [20] The AO group in Switzerland reported success using the compression plate in the treatment of forearm fractures in the late 1950s and early 1960s, Rosacker and kopta found that the most important factors, regardless of the type of fixation used, were anatomical reduction of the fracture and secure fixation. Anderson et al reviewed experience with the first 244 patients with 330 acute diaphyseal fractures of the radius and ulna treated with the ASIF compression plates, the overall union rate was 97.9% for the radius and 96.3% for the ulna. Excellent functional results also were achieved. The authors concluded that the use of ASIF compression plates for acute diaphyseal fractures of the forearm is a very successful method of obtaining union and restoring optimum functional use of the extremity.

Burwell HN and Charnley AD (1964) [21] plates can be used for displaced fractures at any level. Especially useful for fractures of the distal third or proximal fourth of the radial shaft and of the proximal third of the ulna shaft. With the unacceptable results of closed methods and with the less than excellent results of a variety of intramedullary appliances, numerous investigators, including eggers, Burwell, charnley and others sought more rigid fixation by means of plates and screws.

The dynamic compression plate (DCP) first described by Bagby and Denham and more recently developed by the AO school has an intrinsic compression device making extensive dissection unnecessary. The plate depends upon the obliquity of cylindrical screw holes for compression, which is produced as the screws are driven

home. The most effective method of producing rigid internal fixation is by the use of compression plates developed by the AO school in Switzerland.

C.A. Goldfarb and W.M Ricci et al (2005) [22] aim was correlated the health status with objective and radiological outcomes in patients treated by open reduction and internal fixation for fractures of both bones of the forearm. They assessed 23 patients (24 fractures) subjectively, objectively and radiologically at a mean of 34 months (11 to 72). Subjective assessment used the disability of the arm, shoulder and hand (DASH) and musculoskeletal functional attachment (MFA) questionnaires.

The range of movement of the forearm, wrist, grip and pinch strength were measured objectively and standardized radiographs were evaluated. In general, patients reported good overall function based on the DASH (mean 12 : range 0 to 42) and MFA (mean 19 : range 0 to 51) scores.

Lichter L Rowlin and Torsten Jacobson (1975) [23] observed tardy palsy of the posterior interosseous nerve with a monteggia fracture. Acute nerve injuries must be documented at the time of injury by a thorough physical examination, paying particular attention to the terminal branches of the radial and median nerves. Nerve deficits occurring after surgical procedures that were not present preoperatively nearly always involve either the radial or median nerve. These injuries are usually due to pressure over the radial head during reduction or overzealous retraction.

Marya KM and Devgan A et al (1999) [24] presented scientific paper on limited contact dynamic compression plates for adult forearm fractures. They have reviewed of

patients with closed diaphyseal fractures of one or both forearm bones treated by limited contact dynamic compression plates. There were excellent results in terms of fracture union and function after an average follow up period of 2.5 years.

Larry D. Iversen and Marc F. Seinotkowski (1994)[1] in adults, it is difficult to achieve a satisfactory closed reduction of displaced fracture of the forearm bones and if achieved, it is hard to maintain. Unsatisfactory results of closed treatment have been reported to range from 38% to 74%. For this reason, open reduction with internal fixation is routine except for undisplaced fractures. Undisplaced single bone fracture should be treated in a long arm cast until there is roentgenographic evidence of union or definitive evidence of delayed union.

Rosacker J.A. and Kopta J.A. (1981) [25] The AO group in Switzerland reported success using the compression plate in the treatment of forearm fractures in the late 1950s and early 1960s, found that the most important factors, regardless of the type of fixation used, were anatomical reduction of the fracture and secure fixation.

Campbell's Operative Orthopaedics [26] with compression plate fixation, early active motion is possible. This helps prevent muscle atrophy and joint stiffness, which often are responsible for unsatisfactory results. Chapman et al reviewed 129 diaphyseal forearm fractures treated with compression plates and found 90% fracture union and 92% satisfactory result.

M.E. Muller and M. Allgower et al (1995) [27] transverse and short oblique factures cannot be stabilized with lag screws but can be brought under compression with a plate. The plate acts as a static compression plate and exerts compression in the direction of the long axis of the bone. This can be accomplished either by taking advantage of the DCP holes alone or by adding the tension device. It must be appreciated that, the most efficient and the most stable means of achieving interfragmentary compression is by the lag screw. Therefore whenever possible, axial compression plates should be combined with lag screw fixation.

Ronald McRae and Max Esser (2002) [28] in the adult displacement, angulations, rotation and comminution may be quite marked and closed reduction is often difficult or impossible to achieve. The best treatment for displaced fractures of the forearm bones in the fit adult is open reduction and internal fixation, usually by placing both bones through separate incision. 3.5 mm AO dynamic compression plates are commonly used, with the radial plate contoured to fit the curve of the shaft.

Boreau and Hermann (1952) [29] introduced a plate with two parts in which a cylindrical bolt forced the fragments together.

Babgy and Janes (1958) [30] modified a collision plate with oval holes, allowing compression to be achieved by eccentric placement of the screws.

Naiman. P.T. and Co-workers (1970) [31] reported a series of diaphyseal fracture of the radius and ulna treated by compression plates. In naiman and coworkers series, all 30 fractures united.

Dodge HS and Cady GW (1972) [32] also encountered no nonunion in their 78 patients in whom compression plates were used. However, ten infections occurred, the incidence was 3% in closed fractures and 36% in open fractures.

Teipner WA and Mast JW (1980)[33] in 1980 published a study comparing double plating with single compression plating for diaphyseal fractures of the forearm. Fifty-five patients with 84 fractures were treated using the double-plating technique. In this group 82 unions and two non-unions. They used a single compression plate in 48 patients with 70 fractures. All 70 of these fractures progressed to union and the authors reverted to the single compression plate technique almost entirely.

Stern PJ and Drury WJ [34] in 1983 reported 54 patients with two bone fractures of the forearm treated with various fixation devices. There were 108 fractures in the 54 patients. The highest percentage of fractures that were anatomically reduced was those treated with compression plates.

Schiemitsch EH and Richards RR (1995) [35] observed 55 adult patients with fractures of both bones of the forearm treated by plating for a mean of 6 years (range, 1 to 16 years). A complete functional and radiographic assessment was performed at follow-up. Malunion was quantified by measuring the amount and location of the

maximum radial bow in relation to the opposite, normal forearm. Fifty-four of the radial and 54 of the ulna fractures united.

Mich AD et al (1994) [36] in a series of 175 patients treated with forearm plating for diaphyseal fractures, found that 5 of 113 patients who retained their internal fixation experienced a complication related to the plate. In contrast, ten of 62 patients who had their plates removed experienced major complications. The difference between the two groups of patients was statistically significant.

Deluca PA and co-workers (1988) [37] reported refracture in seven of 67 patients. Refracture occurred between 42 and 121 days after plate removal. In their series, fracture always occurred through the original fracture site. The average time from original injury to plate removal in refracture was 16 months. No refracture were seen in patients if the plates were removed after 24 months.

Beaupre GS and Csongradi JJ (1996) [38] reviewed 401 patients who had 459 plates removed from the forearm. Thirty-seven refracture occurred in 29 patients. The re fracture rate was 21% after removal of large fragment dynamic compression plates and 5.6% after removal of small fragment dynamic compression plates. The considerable re fracture rate and other factors described above suggest that large fragment dynamic plates should not be used to treat fractures of the forearm.

Littlefield WG and associates (1992) [39] reported on five patients with digital flexion contractures after healed forearm fractures that were initially diagnosed as mild

volkmann ischemic contractures. Lyses of adhesions and lengthening of the contracted muscles corrected the deformities.

Langkamer VG and Ackroyd CE (1990) [40] reported complications in 22 of 55 patients who underwent elective plate removal. Before removal only 20 patients had reported definite symptoms attributable to the plate. Fifty percent of the complications incurred during plate removal were permanent.

Rhinelander FW (1968) [41] has shown that after fracture, the Periosteal circulation becomes dominant, primarily through dense connective tissue attachments. Careless soft tissue technique adversely affects bone healing through circulatory impairment.

Schenk RK and Willenegger HR (1977) [42] have done studies of bone healing under rigid fixation. They have shown that where bone is under compression such that no fracture gap is present, dead bone is resorbed, resorption cavities produced by cutting cones of osteoclasts, traverse the fracture plane. Blood vessels accompanied by mesenchymal cells and osteoblast precursors soon follow to reconstitute the haversian systems.

Paavolainne P and associates (1979) [43] also studied the healing of experimental fractures in rabbit tibiofibular bones that were fixed by six-hole stainless steel dynamic compression plates. These fractures were tested for torsional strength at intervals from 3 to 24 weeks postoperatively. During the first 9 weeks, there was progressive

improvement in maximum torque capacity, energy absorption and torsional rigidity, reflecting the advancement of the union. From 9 to 24 weeks, the torque capacity and energy absorption decreased, whereas torsional rigidity reached a steady state. The authors concluded that after healing, the continued presence of the implant has an adverse effect on the cortical bone, which loses strength.

Pilliar RM and associates (1979) [44] applied a porous coating of cobalt based alloy on the surface of 316L stainless steel plates. The powder was sintered to the plates in hydrogen at 1,270˚ C. The control was a steel plate annealed at 1,270˚ C for 3 hours. Six months after applying the plates in dogs, there was no difficulty in prying the control plates off, but the coated plates were removed only with great difficulty. There was greater intracortical porosity and bone resorption on the side of the coated plate.

Uhthoff HK and co-workers (1981) [45] have compared stainless steel and titanium plates in the healing of osteotomies in beagles and found that radiological bone loss was 19% for stainless steel and only 3% for the titanium plates.

Ganz R, Vander Werken C and Mast et al (1993) [46] are developing percutaneous plate insertion method with little or no bone plate contact. Small skin incisions are made for plate insertion and screw placement. Fracture reduction is indirect and plating is applied subfascially, with little disturbance of soft tissues. Plates are locked to the screws with 4.5 mm nuts applied under the plate. Long

bone fractures stabilized with plates applied in this manner resemble interlocking nails.

Tscherne H et al (1986) [47] have measured the magnitude of prestressing with transverse fractures. Data from their work are presented. Prestressing of a compression plate applied to the tension side of a bone produces an enhanced dynamic tension band effect.

Bynum D Jr and associates (1971) [48] found that no benefit occurred from increasing either the breadth of the plate or the size of the screws, but when the plate was increased in length from 3 to 6 inches the strength of the assembly was doubled.

DYNAMIC COMPRESSION PLATE (DCP)

The dynamic compression plate (DCP) first described by Bagby and Denham (1956) and more recently developed by the AO school has an intrinsic compression device making extensive dissection unnecessary. The plate depends upon the obliquity of cylindrical screw holes for compression which is produced as the screws are driven home. The most effective method of producing rigid internal fixation is by the use of compression plates developed by the AO school in Switzerland.

Plates :

Function

Plates are devices, which are fastened to bone for the purpose of providing fixation. They are principally differentiated by their function. Thus they are protection

or neutralization plates, buttress plates, compression plates and tension band plates. The shape of the plate is an adaptation of the plate to the local anatomy and does not denote any function. Thus straight and angled blade plates can function as protection plates, tension band plates or buttress plates. The name depends on the biomechanical function the plate is performing.

In Study in 1989 Chapman et al reported an excellent or satisfactory functional result in 92% of their patients, with an infection rate of 2.3 %, Fixation using an LCP is an effective treatment method in terms of union rate, pain and functional outcomes [3] "Biological Fixation" and the use of locked plates attempt to create a biomechanical environment entirely different from that obtained with compression plating. Fracture surfaces are not compressed and a bridging fixator allows a small amount of elastic motion at the fracture site

In their another study by Leung, sp chow, The locking Compression plate (LCP) was devised by combining the features of an LC-DCP and a PC-Fix. They concluded although LCPs have theoretical advantages, clinicians are responsible for evaluating their efficacy through well planned trials and accurate documentation [64]

Another study shows that LCP enables usage of a variety of standard and locking head screw to achieve fixed angle stability. The number of screws to be inserted and the choice of standard or locking head screws and monocortical or bicortical screws may all have an effect on the mechanism of fracture healing. In studies by michael j. gardner, helfet, and dean g. lorich shows the increasing size of the

elderly population and incidence of osteoporosis, fixed angle constructs may lead to improved stability in poor quality bone.

SURGICAL ANATOMY OF FOREARM

Surgical anatomy of the forearm is very essential to understand the mechanism of injury and deforming forces.

Radius: This bone carries the hand and is stabilized against the ulna for pronation-supination and against the humerus for flexion-extension of the forearm. From a cylindrical head the bone tapers into a narrow neck. The shaft becomes increasingly thick as it curves down to the massive lower extremity. The head is cylindrical and is covered with hyaline cartilage. It is palpable in the depression behind the lateral side of the extended elbow, where it can be felt rotating in pronation- supination movements. A spherical hollow forms the upper surface, to fit the capitulum. The cylindrical circumference is continuous with this hollow and is deepest on the medial side of the curvature, it articulates with the radial notch of the ulna and with the annular ligament. The synovial membrane of the elbow joint is attached to the articular margin, but head and neck are free of any capsule attachment, to rotate in the clasp of the annular ligament, which normally holds it in place, a sudden jerk on the hand of a child may avulse the head from the ligament.

The ulna surface shows a notch for articulation with the head of the ulna. Above this is a triangular area enclosed by anterior and posterior ridges into which the interosseous border divides. The interosseous membrane is attached to the posterior ridge. In front of it lie the sacciform recess and then the deepest fibers of pronator

quadratus are attached to the front of the triangle. Inferiorly is the articular surface for the wrist joint, two concave areas covered with hyaline cartilage. The ulna (medial)surface is square, and articulates with the lunate. It continues into the hyaline cartilage of the ulna notch, but in the intact wrist the triangular fibro cartilage is attached to the right-angled border between the two and divides the distal radioulnar and wrist joints from each other.

Surgical approach

The head is exposed as for the lateral approach to the elbow joint by detaching the common extensor origin from the lateral epicondyle of the humerus and incising the capsule. The shaft is exposed from the front. At the upper end brachioradialis and the two radial extensors are mobilized laterally by cutting the radial recurrent artery and any relevant muscular branches, then supinator with its underlying periosteum is carefully detached from the bone. Remember that the radial artery is lateral to the flexor carpi radialis tendon and the median nerve medial to it.

Ossification

A hole appears in cartilage at the sixth week and a center appears in the middle of the shaft at the eighth week. At birth both ends are cartilaginous, the lower is the growing end. A center appears in the lower end at the end of the first year and fuses at 20 years. This epiphyseal line is extra capsular, it runs transversely through the base of the styloid process and lies above the ulnar notch. The center for the head appears at 4 years and fuses at 12, the epiphyseal line is at the junction of head and neck.

ULNA : This is the stabilizing bone of the forearm. It obtains a good grip of the humerus and on this foundation the radius and hand move in pronation-supination to

secure the appropriate working position for the hand. The ulna tapers in the reverse way to the radius, it is massive above and small at its distal extremity, where the head is situated. The upper end has two projections, with a saddle shaped articular surface between them. They are the olecranon and coronoid process and they grip the trochlear surface of the humerus. The olecranon is the proximal extension of the shaft, subcutaneous and easily palpable and in extension of the elbow, it is lodged in the olecranon fossa of the humerus. Its upper surface is square and receives the tendon of triceps over a wide area, which is smooth. Its anterior border forms a sharp undulating tip at the articular margin, the capsule of the elbow joint is attached just behind the tip. The posterior surface, triangular in shape, is subcutaneous, the olecranon bursa lies on it. The medial surface of the olecranon, gently concave, is continued down to the flexor surface of the shaft.

Surgical approach

Being subcutaneous at the back, the bone is easily exposed by incising along the posterior border. The periosteum is elevated and the aponeurotic origins of flexor carpi ulnaris and digitorum profundus retracted medially and that of extensor carpi ulnaris retracted laterally.

ANTERIOR COMPARTMENT OF THE FOREARM

The flexor muscles in the forearm are arranged in two groups, superficial and deep. The five muscles of the superficial group cross the elbow joint, the three muscles of the deep group do not.

Superficial muscles These five muscles are distinguished by the fact that they possess a common origin from the medial epicondyle of the humerus, at its anterior surface. Three of the group have additional areas of origin. The common origin attaches itself to a smooth area on the anterior surface of the medial epicondyle, there is but little flesh attached to the humerus.

Pronator teres

Arising from the common origin and from the lower part of the medial supracondylar ridge, the main superficial belly is joined by the small deep head, which arises from the medial border of the coronoid process of the ulna just distal to the sublime tubercle.

Nerve supply. By the median nerve (C7,8).

Action. It is a flexor of the proximal interphalangeal joints and secondarily of the metacarpophalangeal and wrist joints. It also assists in flexion of the elbow and wrist.

Palmaris longus. Functionally negligible, this muscle is of morphological interest. It is absent in 13% of arms. It is phylogenetically degenerating and shows the characteristics of this, i.e. short belly and long tendon (like plantaris in the leg).

Nerve supply. By the median nerve (C7,8).

Action. It is a weak flexor of the wrist and by its attachment to the palmar aponeurosis, it may produce minimal flexion at the metacarpophalangeal joints of the fingers.

Flexor carpi radialis

Arising from the common origin the fleshy belly lies distal to pronator teres. In the middle of the forearm the flesh gives way to a flattened tendon, which becomes

rounded at the wrist, where it runs through its own compartment in the flexor retinaculum and then lies in the groove of the trapezium.

Nerve supply. By the median nerve (C6,7).

Action. It is a flexor and radial abductor of the wrist and assists in pronation of the forearm and flexion of the elbow.

Flexor digitorum superficialis

It arises from the common origin, the medial ligament of the elbow joint and the sublime tubercle on the medial border of the coronoid process of the ulna (humeroulnar head).

Nerve supply. By the median nerve (C7,8).

Action. It is a flexor of the proximal interphalangeal joints and secondarily of the metacarpophalangeal and wrist joints.

Flexor carpi ulnaris

Arising from the common origin, the muscle receive a further contribution from a wide aponeurosis which arises from the medial border of the olecranon and the upper three-fourths of the subcutaneous border of the ulna.

Nerve supply. By the ulnar nerve (C7, 8) through two to four branches.

Action. It is a flexor of the wrist, an ulnar adductor when acting with extensor carpi ulnaris.

Deep muscles

The group consists of flexor digitorum profundus, flexor pollicis longus and pronator quadratus.

Flexor digitorum profundus

The most powerful and the bulkiest of the forearm muscles, it arises by fleshy fibers from the medial surface of the olecranon, from the upper three fourths of the medial and anterior surface of the ulna .

Nerve supply. By the anterior interosseous branch of the median nerve and by the ulna nerve (C7,8).

Action. It flexes the terminal interphalangeal joints and still action, rolls the fingers and wrist into flexion.

Flexor pollicis longus

This muscle arises from the anterior surface of the radius below the anterior oblique line and above the insertion of pronator quadratus.

Nerve supply. By the anterior interosseous branch of the median nerve (C8,T1).

Action. It is the only flexor of the interphalangeal joint of the thumb and also flexes the metacarpophalangeal and carpometacarpal joints of the thumb and the wrist joint.

Pronator quadratus

Arising from the lower fourth of the ulna, especially from the sinuous ridge on its anteromedial aspects.

Nerve supply. By the anterior interosseous branch of the median nerve (C8, T1).

Action. The muscle pronates the forearm and helps to hold the lower ends of the radius and ulna together, especially when the hand is weight bearing.

VESSELS OF THE FLEXOR COMPARTMENT

Radial artery

The radial artery passes distally medial to the biceps tendon, across the supinator, over the tendon of insertion of the pronator teres, the radial origin of flexor digitorum superficialis, the origin of the flexor pollicis longus, the insertion of pronator quadratus and the lower end of the radius.

Ulnar artery

The ulnar artery disappears from the cubital fossa by passing deep to the deep head of pronator teres and beneath the fibrous arch of the flexor digitorum superficialis near the median nerve. Its chief branch is the **common interosseous,** which divides into anterior and posterior interosseous branches. The **anterior interosseous artery** lies deeply on the interosseous membrane between flexor digitorum profundus and flexor pollicis longus, supplying each. The **posterior interosseous artery** disappears by passing backwards through the interosseous space above the upper end of the interosseous membrane, but distal to the oblique cord.

NERVES OF THE FLEXOR COMPARTMENT

The **lateral cutaneous nerve of the forearm**, the cutaneous continuation of the musculocutaneous nerve. The **medial cutaneous nerve of the forearm** is roughly

symmetrical with the lateral cutaneous nerve. The superficial branch of the **radial nerve**, the cutaneous continuation of the main nerve, runs from the cubital fossa on the surface of supinator, pronator teres tendon and flexor digitorum superficialis .

The **median nerve,** while still in the cubital fossa, gives a branch to pronator teres then disappears between the two heads of that muscle. The median nerve gives off an **anterior interosseous** branch which runs down with the artery of the same name and supplies flexor digitorum profundus (usually the bellies). It has no cutaneous branch. Just above the flexor retinaculum the median nerve give off a **palmar branch** to the skin over that muscle.

The **ulnar nerve** enters the forearm from the extensor compartments by passing between the humeral and ulnar heads of origin of flexor carpi ulnaris.

RADIOULNAR JOINTS

The **proximal radioulnar joint** has been mentioned in connection with the elbow joint. The essential structure here is the **annular ligament** which imprisons the head of the radius. The annular ligament is attached to the radial notch of the ulna and its fibers encircle the head and neck of the radius.

The **distal radioulnar joint** is closed distally by a triangular fibro cartilage, which is attached by its base to the ulnar notch of the radius and by its apex to a small fosse at the base of the ulnar styloid.

POSTERIOR COMPARTMENT OF THE FOREARM

A dozen muscles occupy the extensor compartment. At the upper part are anconeus (superficial) and supinator (deep).

Brachioradialis Arising from the upper two-thirds of the lateral supracondylar ridge, the muscle passes along the preaxial border of the forearm.

Nerve supply. By the radial nerve (C5,6) from a branch arising above the elbow joint.

Action. Its action is to flex the elbow joint.

Extensor carpi radialis longus

Arising from the lower third of the lateral supracondylar ridge of the humerus, the muscle passes down the forearm, behind brachioradialis and beneath the thumb muscles, to be inserted as a flattened tendon into the base of the second metacarpal.

Nerve supply. By the radial nerve (C6,7).

Action. It is an extensor and abductor of the wrist and midcarpal joints.

Extensor carpi radialis brevis

This muscle arises from the common extensor origin on the front of the lateral epicondyle of the humerus.

Nerve supply. By the posterior interosseous nerve (C6,7).

Action. As a wrist extensor like its longus companion, it is indispensable in 'making a fist'.

Extensor digitorum

Arising from the common extensor origin the muscle expands into a rounded belly in the middle of the forearm, diverging from the three muscles on the radial side and separated from them by the emergence of the thumb extensors.

Nerve supply. By the posterior interosseous nerve on the back of the forearm (C7,8).

Action. It is an extensor of the digits and also assists in wrist extension.

Extensor digiti minimi

Arising in common with the extensor digitorum, the belly of the muscle separates after some distance and then becomes tendinous.

Nerve supply. By the posterior interosseous nerve (C7,8).

Action. It assists extensor digitorum in extension of the little finger and wrist joint.

Extensor carpi ulnaris

There is an origin from the common extensor tendon, as the muscle slopes downwards, it is completed by an aponeurotic sheet of origin from the subcutaneous border of the ulna.

Nerve supply. By the posterior interosseous nerve (C6,7) in the forearm.

Action. It is an extensor of the wrist and act as a synergist during finger flexion.

Anconeus

This muscle arises from a smooth facet on the lower extremity of the lateral epicondyle.

Nerve supply. By the radial nerve (C7,8).

Action. The muscle produces the small amount of extension and abduction of the ulna that occurs during pronation.

Supinator

This muscle consists of two parts with different origins and passing in different directions.

Nerve supply. Posterior interosseous nerve .

Action. Note that biceps is the powerful supinator of the forearm.

Abductor pollicis longus

This arises from an oblique area on both bones of the forearm and the intervening interosseous membrane.

Nerve supply. By the posterior interosseous nerve (C 7,8).

Action. Its name indicates that it abducts the thumb and it can assist in abduction and flexing the wrist, producing a 'trick' flexion when other flexors are paralyzed.

Extensor pollicis brevis

This arises below abductor pollicis longus from the radius and the adjacent interosseous membrane.

Nerve supply. By the posterior interosseous nerve (C7,8).

Action. It extends the carpometacarpal and metacarpophalangeal joints of the thumb.

Extensor pollicis longus

This arises from the ulna just distal to abductor pollicis longus. It is inserted into the base of the distal phalanx.

Nerve supply. By the posterior interosseous nerve (C7,8).

Action. It extends the terminal phalanx of the thumb and draws the thumb back from the opposed position, assisting in extension and abduction of the wrist.

Extensor indicis

This small muscle arises from the ulna just distal to the former muscle.

Nerve supply. By the posterior interosseous nerve (C7,8).

Action. It extends the index finger, as in pointing as well as assisting extensor digitorum in this movement.

MECHANISM OF INJURY

The mechanisms of injury that cause fractures of the radius and ulna are myriad. By far the most common is some form of **high-speed vehicular trauma,** especially automobile and motorcycle accidents. Frequently the patient is unable to recount the exact mechanism of injury owing to the sudden nature of the accident. Probably most of these vehicular accidents result in some type of direct blow to the forearm. Other causes of direct blow injuries include fights in which one of the adversaries is struck on the forearm with a stick. Monteggia and nightstick fractures frequently result from this kind of blow, but fractures of both bones are often caused by this mechanism as well. Gunshot wounds can cause fracture of both bones of the forearm. Such injuries are commonly associated with nerve or soft tissue deficits and frequently have significant bone loss. Pathologic fractures of the forearm bones are not common. If they are excluded, most of the rest of these fractures result from some type of fall. The force generated is usually much greater than the required to cause Colles fracture. Most forearm shaft fractures resulting from falls occur in athletics or in fall from height.

CLASSIFICATION

AO CLASSIFICATION – RADIUS/ULNA, DIAPHYSEAL SEGMENT.

Type A – are simple (i.e. there is a circumferential disruption of the bone), involving one or both bones.

A1 = Simple fracture of the ulna with an intact radius:

A2 = Simple fracture of the radius with the ulna intact:

A3 = Simple fracture of both bones:

Type B - are wedge fractures i.e. there is a separate (butterfly) segment.

B1 = Wedge fracture of the ulna and an intact radius:

B2 = Wedge fracture of the radius and an intact ulna:

B3 = Wedge fracture of one bone, with a simple or wedge fracture of the other:

Type C – fractures are complex (i.e. they have more than two fragments and even after reduction the pattern is such that there is no contact between the main fragments), one or both bones may be involved.

C1 = Complex fracture of the ulna:

C2 = Complex fracture of the radius:

C3 = Complex fracture of both bones:

Orthopaedic trauma association (OTA) system for the fracture configurations.

Type

1) Linear fractures:
   - Transverse
   - Oblique
   - Spiral

2) Comminuted fractures:
   - Comminuted – less than 50%

- Comminuted – more than 50%

- Butterfly – less than 50%

- Butterfly – more than 50%

3) Segmental fractures:

- Two levels

- Three levels or more

- Longitudinal split

- Segmental comminuted fracture

4) Fracture with bone loss :

- Bone loss less than 50%

- Bone loss more than 50%

-Complete bone loss

SURGICAL APPROACHES TO FOREARM

Surgical approaches to Radius and Ulna

I. Radius :

1) Thompson's approach :

A skin incision is made over the proximal and middle thirds of the radius along a line drawn from the center of the dorsum of the wrist to a point 1.5 cm anterior to the lateral humeral epicondyle. If careless, it is easy to injure the nerve, so a constant watch over the nerve is a must.

The interval between extensor digitorum and extensor carpi radialis brevis is developed. These structures are retracted medially and laterally respectively. The abductor pollicis longus muscle is now brought into view, this muscle is retracted distally and ulnarwards to expose part of the posterior surface of the radius. The dissection is extended proximally between extensor digitorum communis and extensor carpi radialis longus and brevis to the lateral humeral epicondyle. Now the extensor digitorum communis is reflected ulnarwards to expose the supinator muscle. If wider view is needed the extensor digitorum communis is detached from its origin of lateral epicondyle. The part of the radius covered by supinator is exposed by one of the two means. The muscle is freed from the bone subperiosteally and reflected in either proximal or distal direction along with the nerve or the muscle fibers of supinator is divided down to the deep branch of the radial nerve and the nerve is carefully retracted.

2) Henry's anterior approach :

Anterior approach to entire shaft : A longitudinal incision is begun at a point just lateral and proximal to the biceps tendon, in the supinated position of the forearm. Now the incision is extended distally in the forearm along the medial border of brachioradialis and if necessary as far as to the radial styloid. Biceps tendon is exposed by incising the deep fascia on the lateral side. The deep fascia of the forearm is divided in line with the skin incision taking care to protect radial vessels. Radial recurrent artery and vein are identified and ligated, otherwise the contents may retract, resulting in haematoma that may cause ischemic contracture of the forearm flexor muscles. Now the elbow is flexed to 90 degrees to allow more retraction of the brachioradialis and the radial carpal extensor muscles to expose the supinator. Now the bicipital bursa is incised. The supinator muscle

is stripped subperiosteally from the radius and reflected laterally. The deep branch of the radial nerve is carried with it and is protected. Now the forearm is pronated and the radius is exposed by subperiosteal dissection.

II. Ulna:

Boyd's approach:

Since part of the posterior surface of ulna throughout its length lies under the skin, any part of the bone can be approached by incising the skin, fascia and periosteum along this surface. Is used to expose the proximal fourth of ulna and radius. The incision is begun about 2.5 cm proximal to the elbow joint just lateral to the triceps tendon, continued distally over the lateral side of the tip of the olecranon and along the subcutaneous border of the ulna and ended at the junction of the proximal and middle third of the ulna.

The interval is developed between the ulna on the medial side and the anconeus and extensor carpi ulnaris on the lateral side. Then the anconeus is stripped from the bone subperiosteally in the proximal of the incision, to expose the radial head, the anconeus is reflected radially. Distal to the radial head, the dissection is deepened to the interosseous membrane after reflecting subperiosteally that part of the supinator that arises from the ulna. The supinator is peeled from the proximal fourth of the radius and the entire muscle mass, including this muscle, the anconeus and the proximal part of the extensor carpi ulnaris, is reflected radially. This exposes the lateral surface of the ulna and the proximal fourth of the radius.

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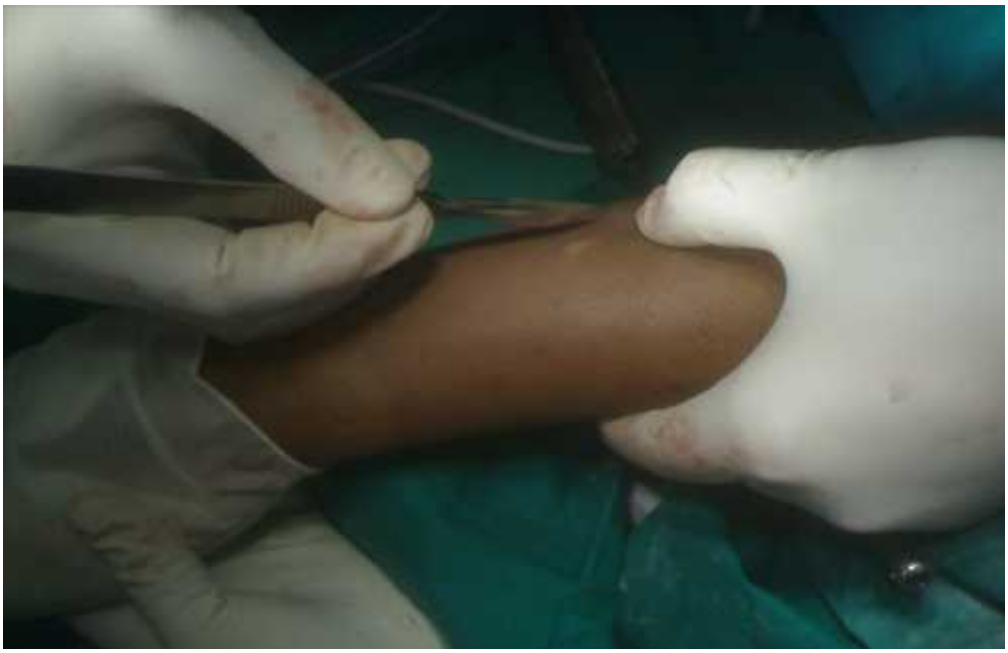


FRACTURE FRAGMENTS APPROXIMATED IN ANATOMICAL ALIGNMENT

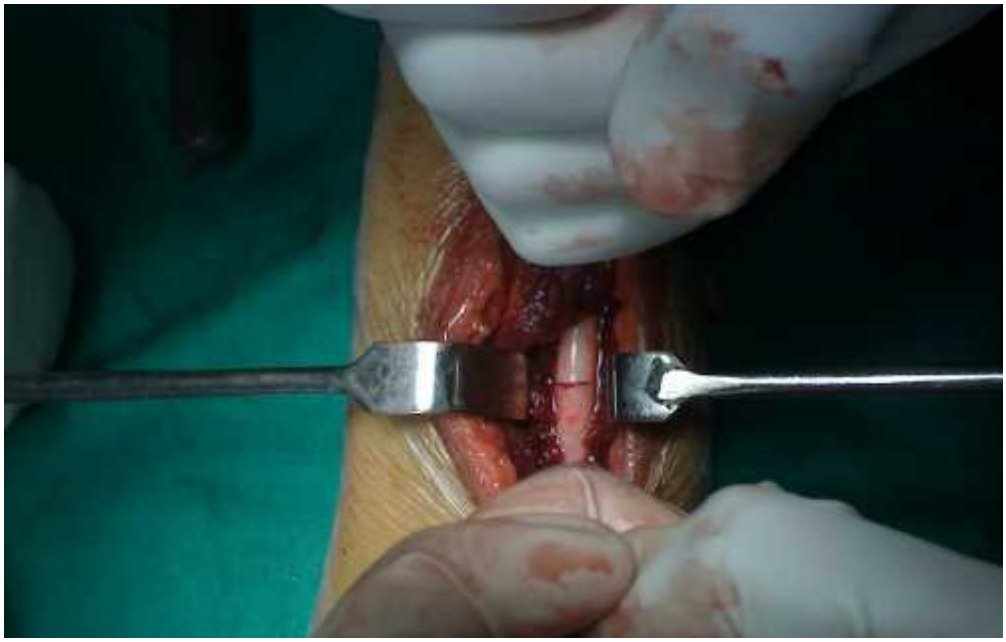


PLATE SECURED TO FRACTURE WITH LOWMAN'S CLAMP

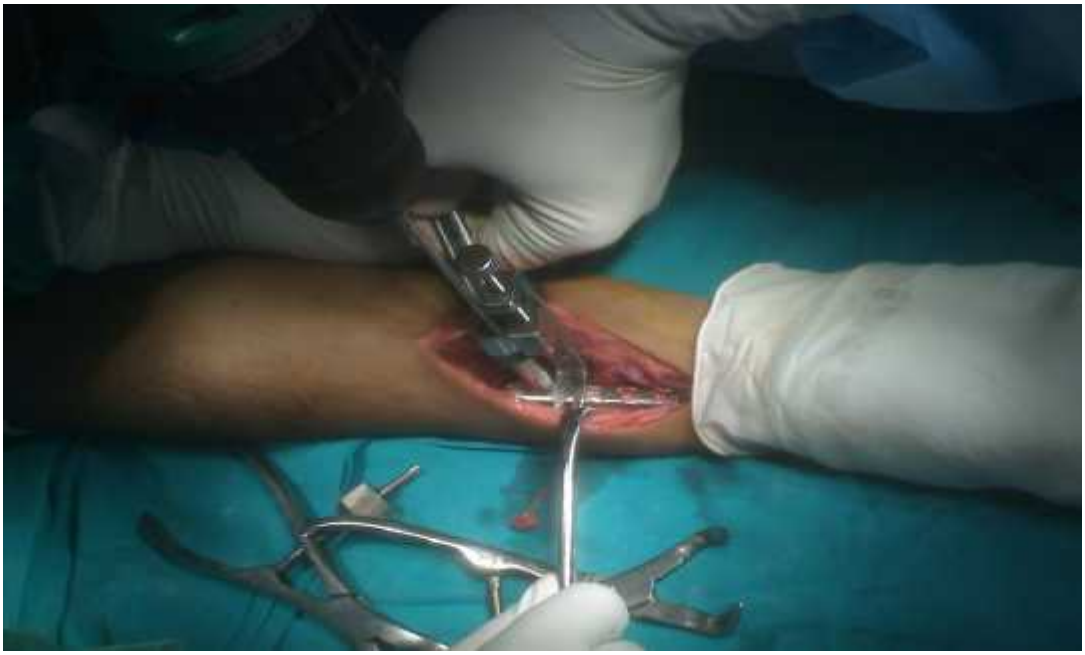
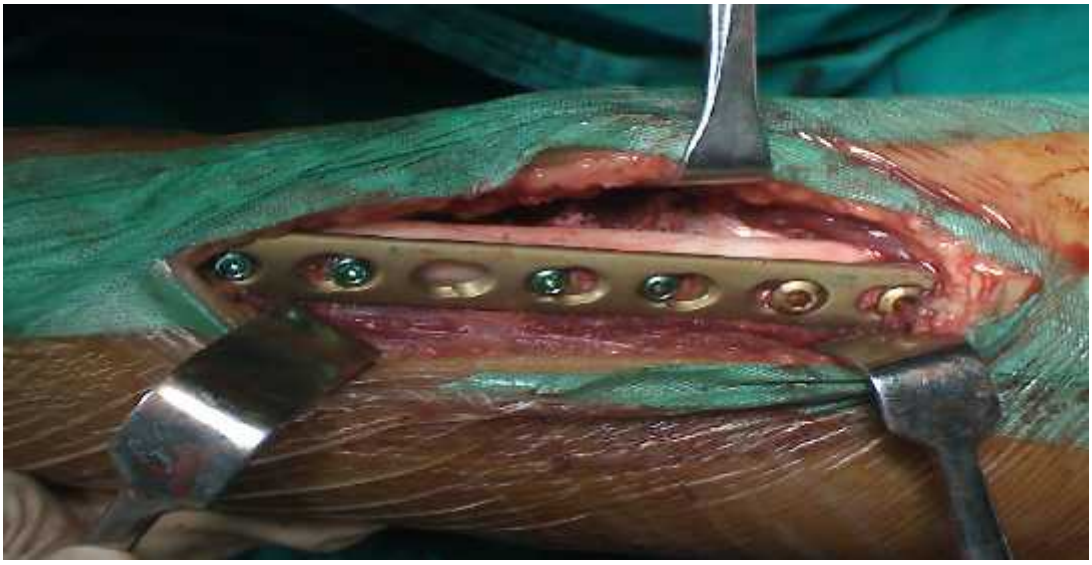
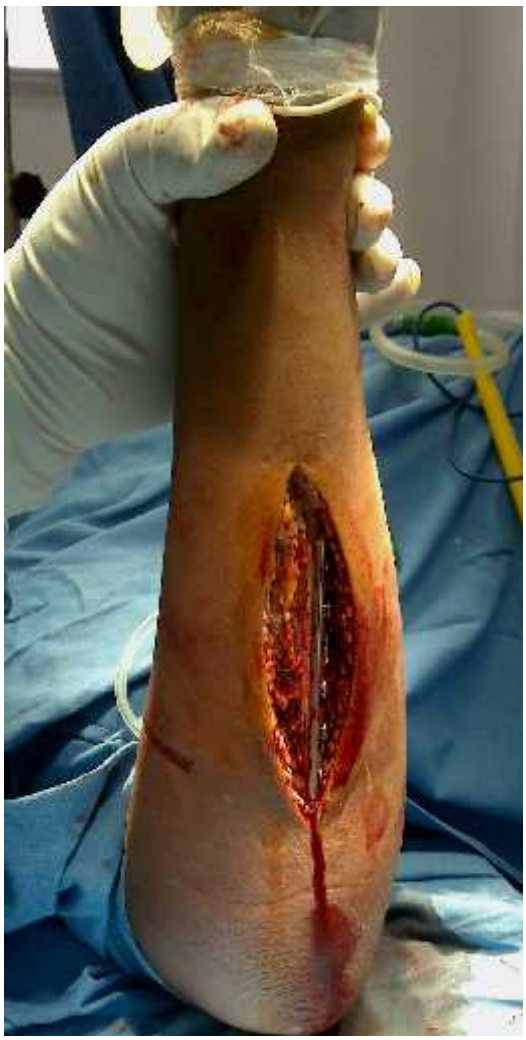


PLATE FIXED TO FRACTURE ENDS





THE LCP CONCEPT

The scientific observations of biomechanics and biology of bone lead to the new concept of biological plating. The newly designed LCP stands for a new approach for plate fixation, reduced trauma to bone, preservation of blood supply, avoidance of producing stress risers at implant removal, the fixed angle construct and excellent tissue tolerance were the goals to be realized. The LCP is technically a further development of the DCP (Perren et al 1979) [6]

The new concept aim at:

1.Minimal surgical damage to blood supply.

2. Improved healing in the critical zone covered by plate.

3. Minimal damage to bone lining the plate to reduce the risk of refracture following plate removal.

4. Optimal tissue tolerance of the implant by selection of pure titanium as an implant material.

The screws are locked in the plates. Due to the resulting angular stability, toggling of the screw is eliminated, thus reducing the risk of reduction loss. No compression of the plate onto the bone is required to achieve stability, this helps to preserve the bone blood supply.

With the unique combination hole it is possible to exploit and combine the advantages of both implant systems, standard plates and screws as well as locked internal fixator.

The combination hole gives compression and absolute stability as with other standard plates and screws. The other hole gives angular stability and better anchorage with locking head screws.

With the conventional plates and screws, anatomical fit between the plate and the bone is necessary in order to maintain an exact reduction. Lag screw technique can be performed to achieve optimal interface compression. Eccentric placement of standard screws allows for dynamic compression.

Due to the combination hole, the LCP system offers an unprecedented range of intra operative options :

Alternative 1: Fixation with standard bone screws.

Alternative 2 : Fixation with locking head screws.

Alternative 3 : Fixation with a combination of standard screws and locking head screws.

When to use the LCP systems-

In all indications where standard plates are used. Metaphyseal multi fragmented fractures benefit in particular, from the option of the combination of standard screws and locking head screws. Fixation with locking head screws is also especially suitable in osteoporotic bones.

Bone Reaction to Compression:

PERREN et al utilized interfragmentary compression to achieve immobilization of osteotomies of sheep tibia. They also demonstrated that bone could tolerate very high static compression without undergoing pressure necrosis [57]

Bone Reaction to Movement:

A fracture which has been rigidly fixed by means of interfragmentary compression (lag screw) demonstrates absolutely no movement between the fragments in very sharp contrast to this fracture which has been stabilized by means of intramedullary nail or external fixator . A fracture, which has been splinted, will always demonstrate movement between the fragments even if only of microscopic dimension.

HUTZSCHEREUTTER et al in 1969 illustrated that the amount of callus is directly proportional to the relative movement between the fragments. PERREN et al demonstrated that resorption at the interface between implant and bone is the result of inadequate pre-stress between the contact surface, which in turn is directly related to the pre-stress of the implant. If under functional loading, a force is generated which is opposite in direction to the pre-stress, but equal to or greater than the pre-stress, the contact surfaces will become unloaded and may even become loaded in the opposite to the original pre-stress. This signifies micro-instability and micro-movement at the contact surfaces, which leads to resorption. The same applies to fractures. When a fracture is stably fixed, no micro-movements occur and therefore no resorption occurs. When stable fixation is not achieved as in the closed treatment the resorption at fracture ends is the characteristic feature of such treatment.

3.5 mm LCP

Biomechanics:

The design goals of the LCP are to increase the stiffness of the construct while maintaining the biological fracture environment. There are distinct differences between the design of conventional bone plates and locking plates. Conventional plates depend on friction at the plate-bone and screw-bone interfaces to maintain fracture fixation. These implants fail due to cortical screw toggling which leads to screw loosening and loss of plate-bone fixation. Therefore, the system depends on each screw's resistance to loosening and pull-out strength.

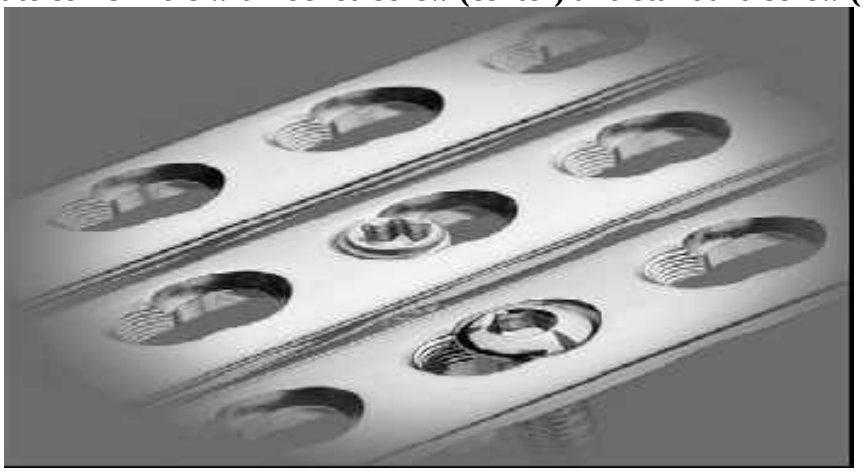
The LCP is a fixed angle construct that does not rely on friction at the plate-bone and screw-bone interfaces. Rather, the system relies on friction at the threaded screw-plate interface. Once the screw is locked into the plate, the fixed, angle stable design converts shear stress into compressive stress at the screw-bone interface. The load applied to the limb is redirected such that it is perpendicular to the screw axis. The redirection of stress explains why locking screws are designed with smaller threads, since they do not generate compression between the plate and the bone. However, they have a larger core diameter which ensures greater bending and shear strength and dissipates the load over a

larger area of bone. In addition, the screws feature the new Star Drive head that with stands 65 percent greater insertion torque than conventional hexagonal drivers. The Star Drive is also self-retaining, thus the screw stays on the screw driver without a holding device.

LCP Implant Design:

The LCP features a uniquely designed combination hole that accepts standard bone screws as well as locking screws, and allows the plate to be used as a conventional plate (compression), a locking plate (internal fixator principle) or as a combination of both principles. The ends of the plate have a "slipper toe" design that facilitates tunneling the bone plate under soft tissues in a minimally invasive manner. The underside of the plate has scalloped undercuts similar to the LCDCP, which creates a uniform area moment of inertia to minimize stress concentration at the plate hole, as well as mitigate disruption of extra osseous blood supply. The locking screws are designed to tolerate the shear loads resulting from angle stable fixation. The core (diameter of the screw between threads) is larger than standard bone screws, with a smaller thread profile. In addition, the pitch of the screw is smaller, and matches the pitch of the thread on the head of the screw.

Locking plate combi-hole with locked screw (center) and standard screw (right).



Disadvantages of LCP

Hardware failure (plate failure or screw breakage) is a complication that has been reported to occur in as many as 7% of the plate fixations.

LCP INSTRUMENTS:

METHODOLOGY

Data is collected from patients presenting with fracture of forearm bone advised to undergo open reduction and internal fixation with plates and screws at KLE Prabhakar Kore Hospital and MRC, Belgaum.

Sample size: 40

On an average 50 cases were operated for plating of forearm bones in one year. Sample size was taken as 40 with equal distribution of cases (using randomization list) i.e. 20 cases with dynamic compression plating (DCP) (Group A) and 20 cases with locking compression plating (LCP) (Group B). Here prospective randomized clinical trial was done using the sealed envelope technique .

Duration : Period of study and follow up was from September 2008 to August 2010.

Study Subjects : All patients who fulfill the selection criteria.

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 and associated neuro vascular injuries.

Age and Sex Distribution:

Off 40 cases there were 35 males and 5 females with equal distribution in both the groups. The average age was 36 years in Group A range (19- 58 years) and was 38.6 years in Group B range (18- 56 years).Refer chart 3,4,5 and 6. Page No-92 and 93.

Mode of Injury:

There were 29 RTAs (72.5%) 10 Falls (25%) and 1 Assault (2.5%). Refer chart 9 and 10 , page No-95.

Distribution of Side, Site and Classification :

The left side was involved in 19 patients and 21 had right side involvement with equal distribution in both the groups. Refer chart 7 and 8,page No-94. A total of 72 bones were fixed in 40 patients of which 37 were ulna and 35 were radius. In Group A there were 15 both bone (75%), 3 isolated ulna (15%), 1 isolated radius (5%) and 1 galeazzi (5%) fracture. In Group B there were 17 both bone (85%), 2 isolated ulna (10%) and 1 isolated radius (5%) fractures. Refer chart 1 and 2, page No-91.

The AO classification was used to know the type of fracture in both the groups. In Group A there were 12 C3, 3 B3, 3 B1, 1A3 and 1 A2. In Group B there were 12 C3, 5B3,2C1 and 1 C2 fractures. Refer table, page No-58.

Type of anesthesia used in both groups were as follows : Brachial block was used in 19 patients (Gr A- 7, Gr B- 12) and general anesthesia was used in 21 patients(Gr A- 13 , Gr B – 8)

All the 37 ulnas were approached directly through the subcutaneous approach. The radius was approached by Henry's anterior approach in 25 patients (Group A-13, GroupB-12) and Thompson's posterior approach in 9 patients (GroupA- 4, GroupB- 5). The average duration of surgery was 78.4 minutes in Group A range (40-145 minutes) and 58.9 minutes in Group B range (30-150 minutes).

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 was then given a posterior slab. All patients were given injectable 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.

Instrumentation :

1. Esmarch / pneumatic tourniquet.
2. Hand drill.
3. Self retaining forceps.
4. Bone hooks.
5. Bone levers.
6. Fracture reduction forceps.
7. Lowman's forceps.
8. Periosteum elevator.
9. 2.8 mm drill bit.
10. Neutral and eccentric drill guide.
11. Depth gauge.

12. 3.5 mm Tap.

13.DCP and LCP Plates, 5- 8 holed.

14.3.5 mm cortical and locking screws from 12-20 mm in length.

15.Hexagonal screwdriver.

Operative procedure:

With the patient under suitable anesthesia , tourniquet was applied to the affected limb in all the patients. 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 fractured, it was approached directly by any of the above- mentioned approaches. But when both bones were fractured, 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. The plate was then applied with lowman's clamp. A plate with at least six holes was chosen, but for spiral and comminuted fractures longer plates with more number of holes was taken.

The fracture that was unstable or comminuted was fixed first followed by stable fracture. The contoured plate was centered across the dorsal side of radial fracture (i.e tensile side of bone) . In ulna the plate was applied either posterolateral or posteromedial side.

The neutral guide directs the drill into the exact center of the plate hole and does not impart any compression. A hole is drilled through both the cortex using 2.8mm drill. Appropriate 3.5 mm screw width was taken and after tapping with 3.5mm tap, the screw was inserted but was not completely tightened.

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.

The contour between the plate and the screw of eccentrically placed screw moves the screw head towards the center of the plate. Locking screw was fixed to the locking plate.

After stable fixation has been achieved, haemostasis was secured meticulously and suction drain was kept before closing the wound.

Post operative management :

Postoperative x- ray were taken, intravenous antibiotics was given for 4 days and later oral antibiotics was given till 1 day before 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.

Later depending on the fracture pattern and fixation, patient was given above elbow slab and advised to do active shoulder exercises.

All the 40 patients were followed up at 4-6 weeks, 11-14 weeks and 6 months for functional and radiological review.

Criteria for Evaluation of Radiological and Clinical Results :

Anderson et al (1975) criteria were used to evaluate radiological and functional results[20]

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 when rigidly compressed.

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	

OBSERVATION

The observations made on the data collected from 20 cases in Group A and 20 cases in Group B is as follows:

Age Distribution:

In our study we had majority of cases (60%) in 20- 30 age group with average of 36 years (19-58) years in Group A and Group B majority of cases (40%) were in 40-50 years with an average of 38.6 years (18-56) years.

Age Group(years)	Group A No of Cases	%	Group B No of Cases	%
<20	1	5	3	15
21-30	12	60	4	20
31-40	4	20	2	10
41-50	1	5	8	40
51-60	2	10	3	15
	20	100	20	100

Sex Distribution :

In both the groups there was equal distribution with males accounting for 87.5% and females 12.5%.

Sex	Group A No of Cases	%	Group B No of Cases	%
MALE	17	85	18	90
FEMALE	3	15	2	10
	20	100	20	100

Side of Fracture:

In both the groups, left side was involved in 45% of cases and right side in 55%.

Side of fracture	Group A No of Cases	%	Group B No of Cases	%
Right	10	50	11	55
Left	10	50	9	45
	20	100	20	100

Mechanism of Injury:

In group A, RTA's accounted for majority of cases (60%) and group B(85%)RTA and Fall has 35% and 15% each and one case of assault (5%) in group A.

Mechanism of injury	Group A No of Cases	%	Group B No of Cases	%
RTA	12	60	17	85
FALL	7	35	3	15
ASSAULT	1	5	-	-
	20	100	20	100

Type of Fracture – AO Classification:

In group A there was majority of C type 60% (comminuted) AO type of fracture and in group B 75% were C type of AO classification.

Type of Fracture	Group A No of cases	%	Group B No of cases	%
A1	-	-	-	-
A2	1	5	-	-
A3	1	5	-	-
B1	3	15	-	-
B2	-	-	-	-
B3	3	15	5	25
C1	-	-	2	10
C2	-	-	1	5
C3	12	60	12	60
	20	100	20	100

Duration of Surgery:

In group A the average duration of surgery was 78.4 minutes in range of (40-145minutes) and in group B it was 58.9 minutes in range of (30-150 minutes).

Duration of surgery (min)	Group A No of cases	%	Group B No of Cases	%
30-46	1	5	3	15
46- 60	2	10	1	5
61- 90	7	35	11	55
91- 120	7	35	4	20
> 120	3	15	1	5
	20	100	20	100

Associated Injuries:

In group A 20% had associated injuries and in group B it was 15%.

Injury	Group A No of cases	%	Group B No of cases	%
Head injury	1	5	-	-
Pneumothorax/ Lung contusion	1	5	1	5
CLW	2	10	-	-
Humerus fracture	-	-	2	10
	4	20	3	15

Hospital Stay:

The average hospital stay was 14 days with majority of cases , 70% in the range of 7-32 days in group A and was 11 days with majority, 75% in the range of 5- 30 days in the group B.

No of Days	Group A No of cases	%	Group B No of cases	%
0-7	2	10	2	10
8-14	11	55	16	80
15-21	6	30	1	5
>21	1	5	1	5
	20	100	20	100

Plate Size Used:

In group A, 6 hole plate was used in 53.2% of cases and in group B, 7 hole plate was used in 64.4% of cases.

Plate size used	Group A No of bones	%	Group B No of bones	%
5 holed	-	-	1	2.8
6 holed	19	53.2	9	25.2
7 holed	12	33.6	23	64.4
8 holed	5	14.0	3	8.4
	36	100	36	100

Level of Fracture:

Majority of cases (64.4%) in group A were at middle third and in group B it was 67.2%.

Level of fracture	Group A No of Bones	%	Group B No of Bones	%
U/3rd	8	22.4	7	19.6
M/3rd	23	64.4	24	67.2
L/3rd	4	11.2	5	14.0
Distal radius	1	2.8	-	-
	36	100	36	100

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 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. Exacting and decisive management is required after fractures of the shafts of the radius and ulna, if function is to be restored.

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 38% to 74%. For this reason, open reduction with internal fixation is routine except for undisplaced fractures.

Undisplaced single bone fracture 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 6 screws engaging three 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. Six to eight hole 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 arm is immobilized in a long-arm plaster cast until there is roentgenographic evidence of union. Reliable patients may be placed in a removable splint and early motion started as soon as wound healing is complete.

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.1990) [12]

Role of compression:

A transverse fracture in a straight segment of a diaphysis will help to explain axial interfragmentary compression. A straight plate is fixed to one fragment and the fracture reduced. The reduction is held with a reduction clamp. A tension device is fixed to the second fragment in such a way that its hook is engaged in the end of the plate and its other end is held to bone by a screw. The spindle of the tension device is then tightened, the plate is brought under tension and the underlying bone compressed. If the bone is now carefully examined, two things will be noted. First, there is a gap in the fracture opposite the plate and second, the bone fragments deep to the plate have been impacted with the fracture line almost vanishing. This type of internal fixation was used by schenk and willenegger (1977) in their early experiments on primary bone healing. The contact of the cortices adjacent to the plate and the gap in the fracture opposite the plate in their work was also documented histologically as contact and gap healing [42]

Determination of union:

Chapman et al 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 LCP (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 (19-58 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 Dodge's 24 years (13-59) in his study. In both the groups, 87.5% of cases in our study were males and 12.5% were females which was almost same compared to dodge's series which was 89% and 11% respectively . The left side was involved in 45% of cases in our study, where as there was 55% involvement of right side in Chapman's series.

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	19	58	36	85	15
Group B	18	56	38.6	90	10
H.DODGE	13	59	24	89	11

The average duration of hospital stay in our study was 14 days in Group A and majority being in 7-32 days and was 11 days in Group B and majority of it being in 5- 30 days, Which has not been mentioned in any of the studies.

A total of 72 bones were fixed in 40 patients of which 37 were ulna and 35 were radius. In Group A there were 15 both bone (75%), 3 isolated ulna (15%), 1 isolated radius (5%) and 1 galeazzi (5%) fracture. In Group B there were 17 both bone (85%), 2 isolated ulna (10%) and 1 isolated radius (5%) fractures compared to Chapman's series which had 42 both bones, 18 radius and 27 ulna in a total of 129 was almost the same, and in P.K. Rai series it was 16, 16 and 5 respectively, where both bones was the commonest type of injury. We had no monteggia and had 1 galeazzi fracture compared to Chapman's 10 and 14 respectively.

Bones Involved (No of Cases):

Series	Fracture BB	Fracture Radius	Fracture Ulna	Total
Group A	15	2	3	35
Group B	17	1	2	37
CHAPMAN	42	18	27	129
P.K. Rai	16	16	5	37

The mode of injury in the present study mostly accounted for RTA (72.5%) compared to S.K. Moda's series was fall, 50% accounted for majority of cases.

The average duration of follow up in our study was 12.95 months (6-20 months) which was almost same as Chapman's follow up which was a average of 12 months. Naiman it was 18 months (8-36 months).

Duration of follow up (months):

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

We used AO classification to classify our fracture pattern. A randomized clinical trail was done equally in both the groups but in spite of which 60% of the cases in Group A were C-type according to AO classification, which were comminuted and rest 30% were B or A type with simple fractures and Group B had 75% of cases of C type and fixed with rigid locking compression plate and this probably could be one of reasons to get better results in Group B.

In Group A we had 22.4 % U/3rd , 64.4% M/3rd , 11.2% L/3rd and 2.8% distal radius fractures and in Group B it was 19.6 %, 67.2% and 14 % respectively compared to Chapman's 17%,60% and 23% were middle third accounted for majority of it in all groups.

Using Anderson's et al criteria for radiological union. In group A, the average time for radiological union was 9.1 weeks (6- 22 weeks) and in group B the average time was 6.4 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 even though radiological callus formation after 6 months were minimal in locking treated group indicating the more rigid fixation and fixed angle

construction in locking plates and this could be the reason for better results in group B.

Radiological Union(Weeks):

Series	Union	Range
Group A	9.1	6-22
Group B	6.4	4-12
Anderson	7.4	5-10

Further using Anderson's et al criteria for functional results, we had 75% excellent, 10% good, 10% fair and 5% poor results in Group A and 90% excellent, 5% good and 5% 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.

Functional results(%):

Series	Excellent	Good	Fair	Poor
Group A	75	10	10	5
Group B	90	5	5	-
Anderson	59	31	7	3
Chapman	83	8	7	2

In our present study we had 2 non union (10%), 1 superficial infection (5%) , 1 loss of movement (5%) and 1 had posterior interosseous nerve palsy (5%)

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 superficial infection (5%), 1 posterior interosseous nerve palsy (5%) and 1 radioulnar Synostosis (5%) .

In our series, we had an overall infection rate of 10%, which is higher compared to Anderson's 2.9% and Chapman's 2.3 % but all 2 cases had superficial infection which promptly treated with intravenous antibiotics and had good bony union.

Complication (%):

Series	Rate of infection	Non union
ANDERSON	2.9	3.7
CHAPMAN	2.3	1.6
Group A	5	10
Group B	5	-

Anderson et at believed that the fracture gap was obliterated or greatly diminished by compression plate and capillaries are able to grow into the medullary callus at an early stage in the healing process. Their integrity is protected by rigidity of the fixation and thus the mesenchymal cells in a well oxygenated environment may readily differentiate directly into osteoblast.

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 locking plates.

CONCLUSION

Forearm fractures **c**ommonly occur due to road traffic accidents in young adults. Open reduction and internal fixation is the treatment of choice as closed methods invariably fail. The fracture fragments should be fixed as early as possible to ease the surgery and it is also important to achieve accurate anatomical reduction with rigid internal fixation. The quality of fixation has a definite bearing on the functional recovery.

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

The 3.5 mm locking compression plating system provides very rigid fixation with compression.

The locking 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 is that locking compression plate (LCP) has a definite advantage over dynamic compression plating (DCP) with respect to the time of union and screw placement in comminuted fractures, but the complications, duration of surgery and surgical technique virtually remains unchanged.

SUMMARY

In our study, 40 patients with closed diaphyseal fractures of one or both forearm bones were treated by open reduction and internal fixation with either locking or dynamic compression plate and screws.

There were 35 males and 5 females with their ages ranging from 18 to 58 years. Among them 32 patients had both bone fractures, 2 patients had isolated fracture shaft radius, 5 patients with isolated fracture shaft ulna and 1 patient had galeazzi fracture dislocation.

All the patients in our study presented with pain, deformity and loss of function of the affected part.

Separate incisions were used for radius and ulna. Thompson's approach was used for upper third of radial fractures. Anterior Henry's approach for lower third of radial fractures and galeazzi fracture dislocations. Ulna fracture was exposed by direct approach. (The subcutaneous border of the ulna between the olecranon and the ulnar styloid process).

In most cases seven holed 3.5 mm either LCP or DCP was used. Postoperative slab protection was given for two weeks in majority of cases.

On an average, the follow up period of these patients varied from six to twenty months. Some of the patients deferred follow up. Radiological union of the fracture occurred in all cases and was satisfactory.

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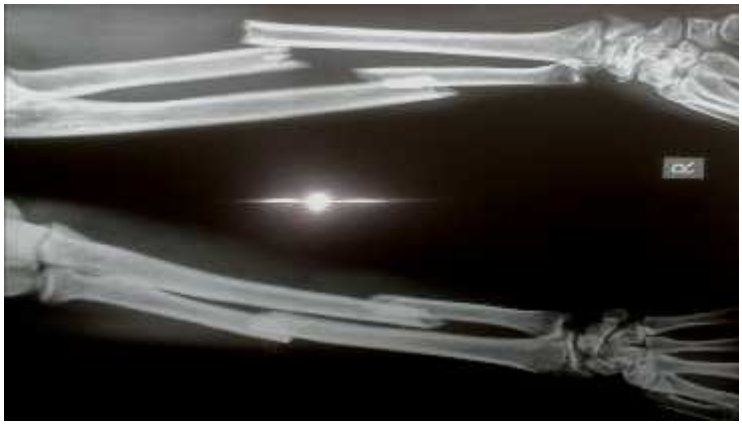
ANNEXURE f - PHOTOS AND CHARTS

DCP TREATED GROUPS

EXCELLENT RESULT



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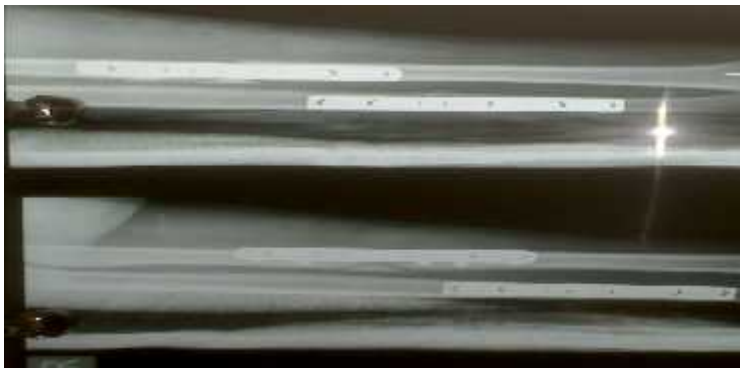

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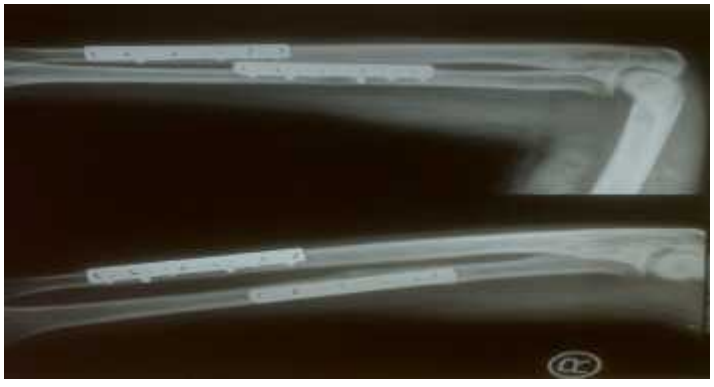

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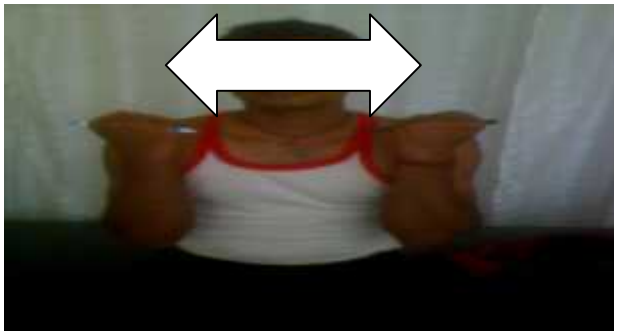

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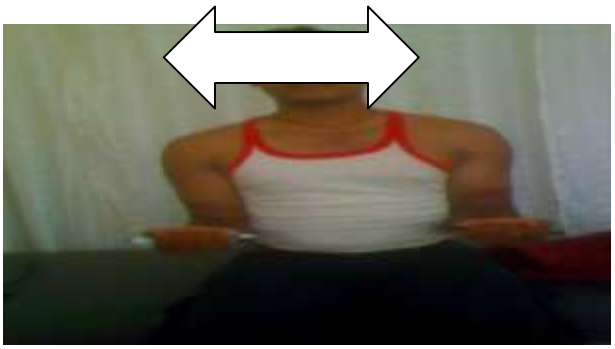
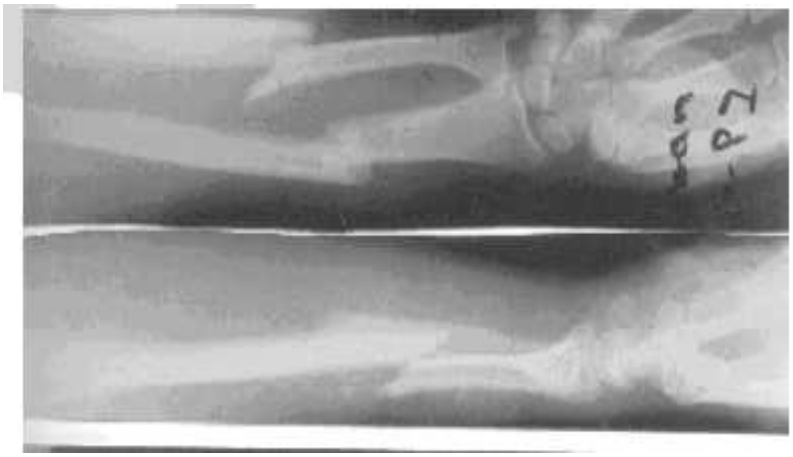


FULL SUPINATION

FULL PRONATION

GOOD RESULT



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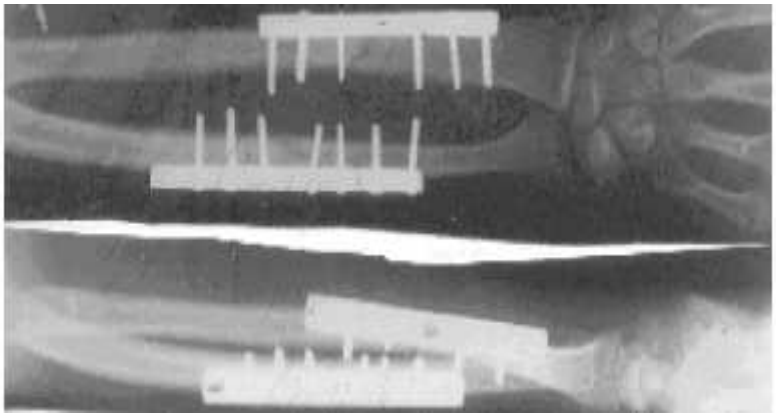

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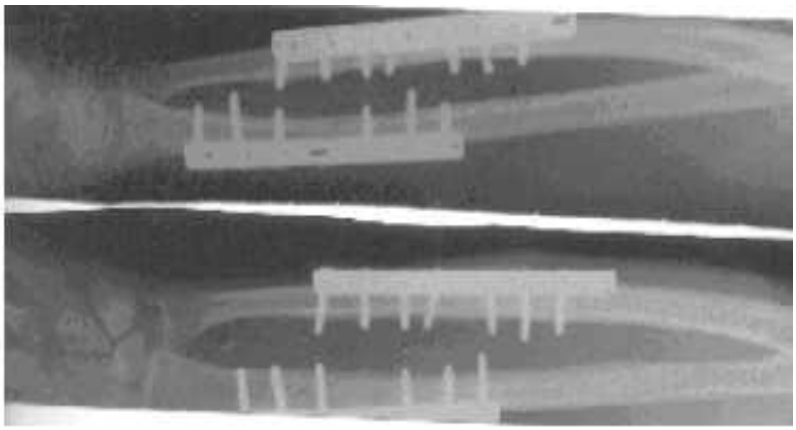

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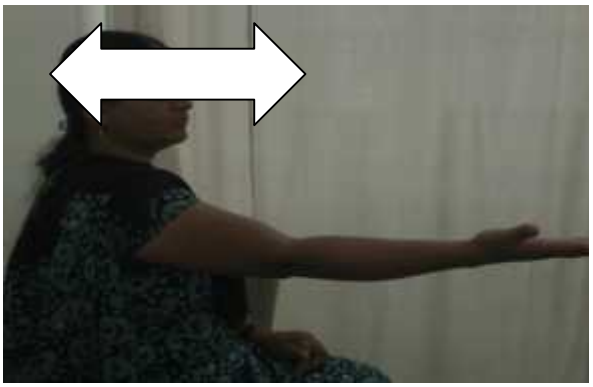

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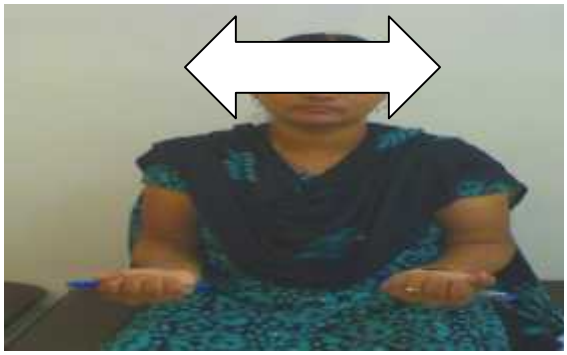
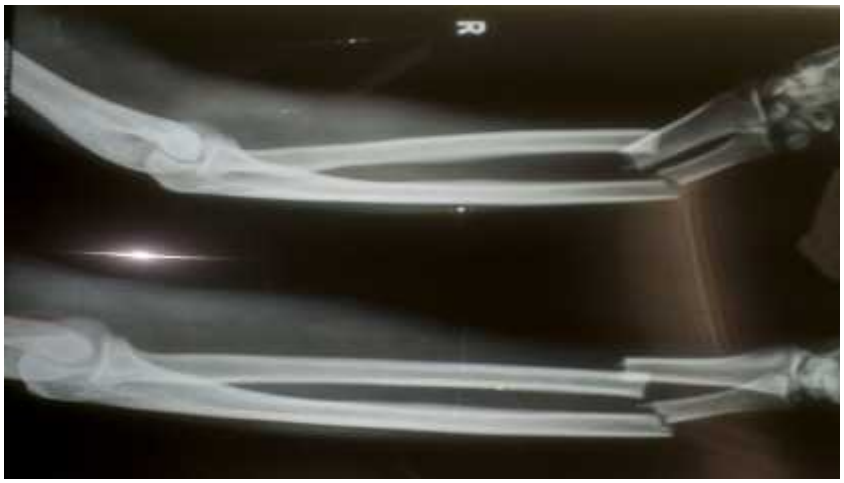


FULL SUPINATION

RESTRICTED PRONATION

FULL FLEXION

FAIR RESULT



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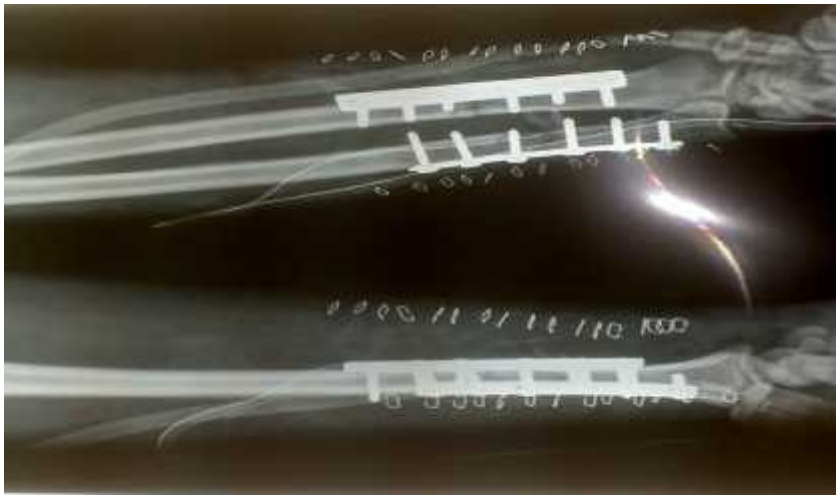

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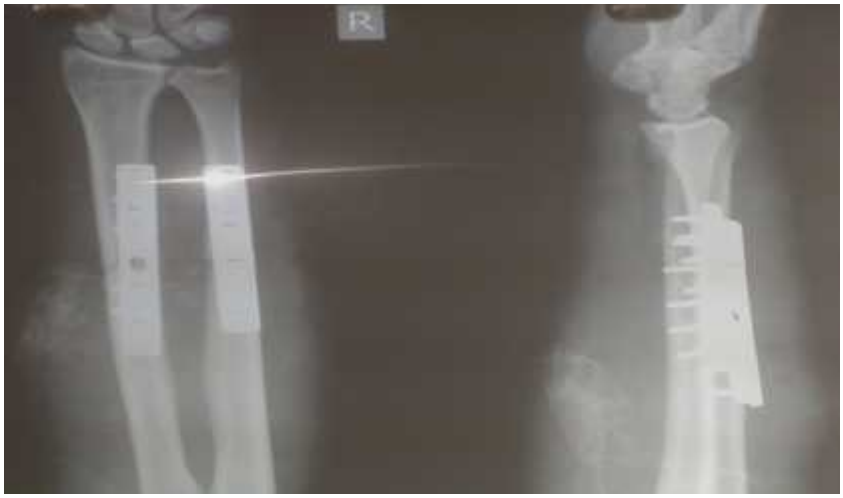

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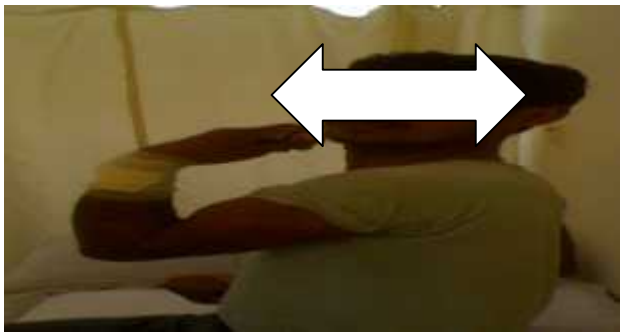

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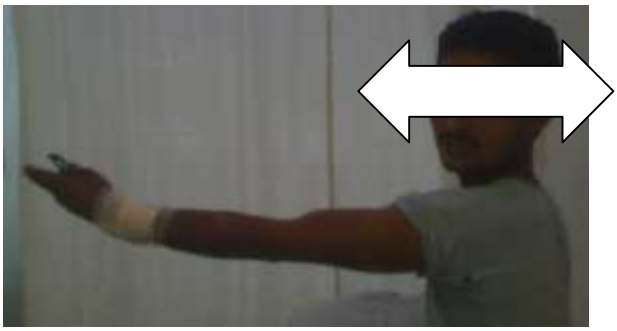
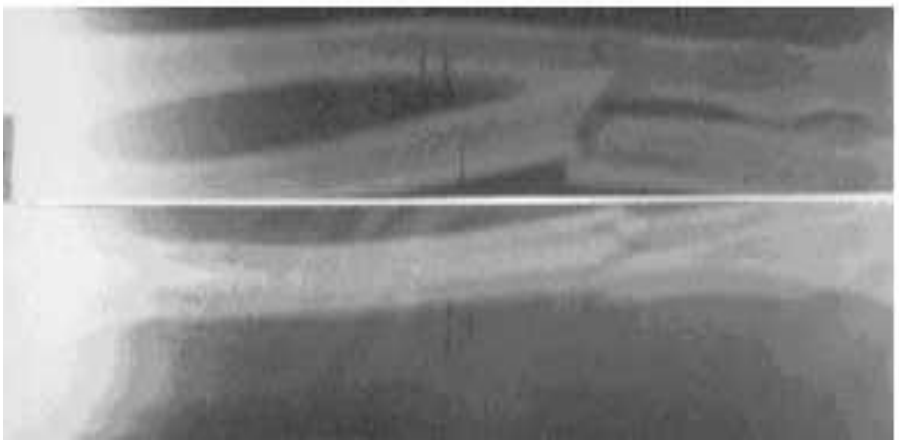


FULL EXTENSION

FULL SUPINATION

RESTRICTED PRONATION

POOR RESULT



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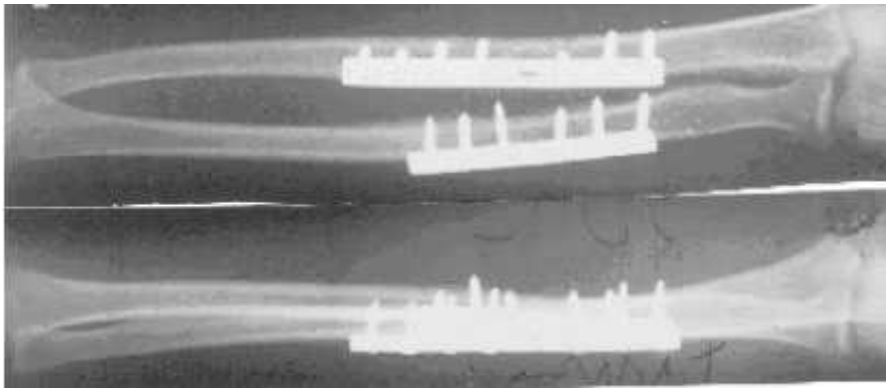

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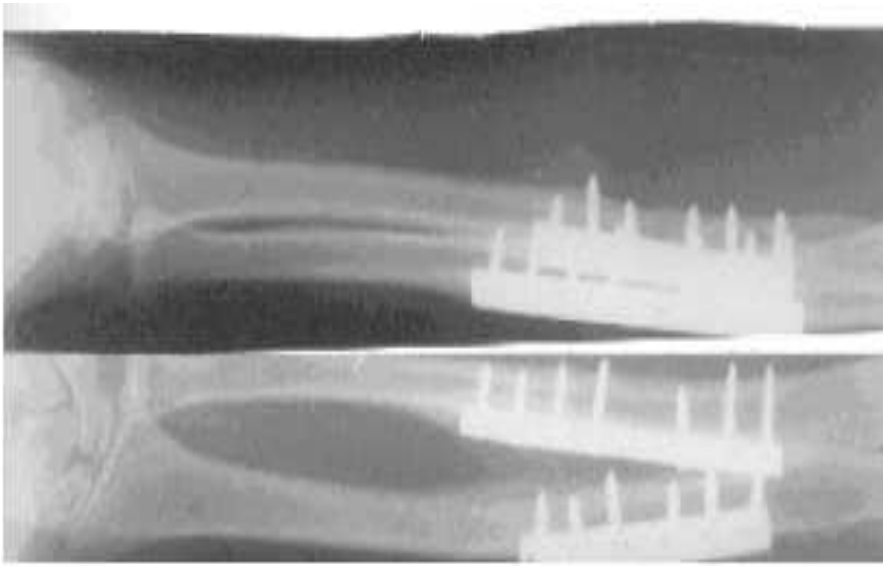


FOLLOW UP X-RAY

FLEXION RESTRICTED

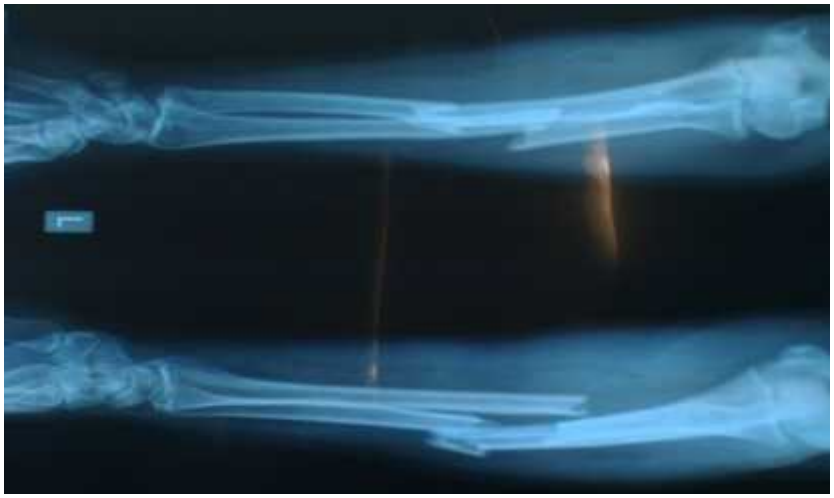
RESTRICTED EXTENSION

RESTRICTED SUPINATION

RESTRICTED PRONATION

LCP TREATED GROUP

EXCELLENT RESULT



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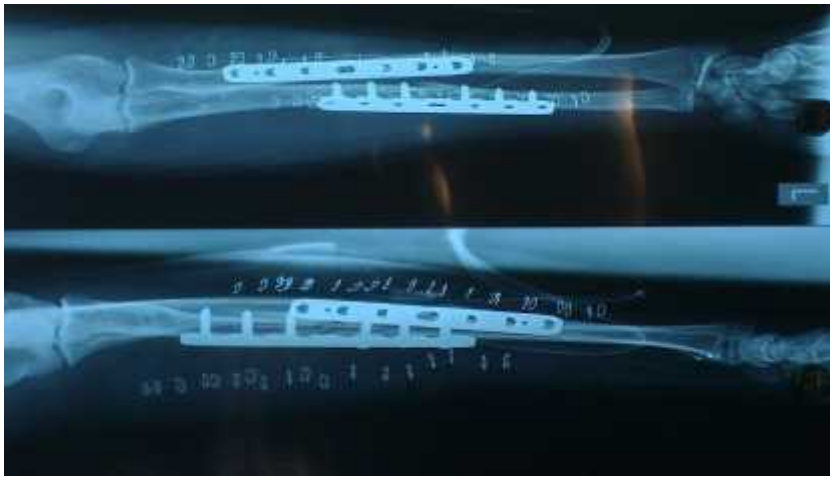

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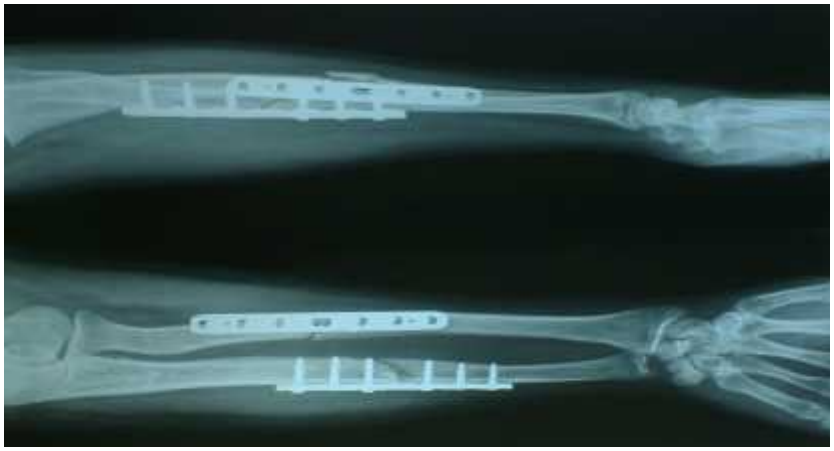

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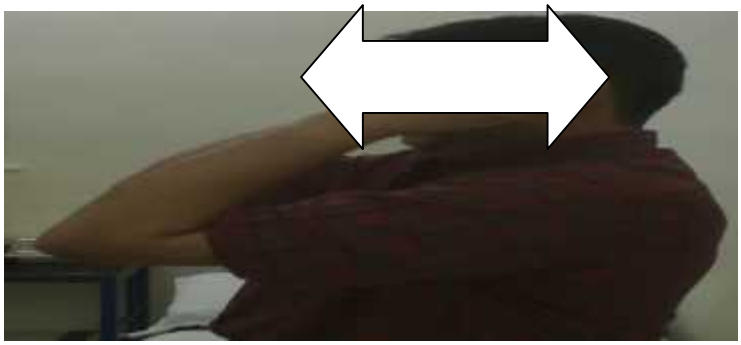

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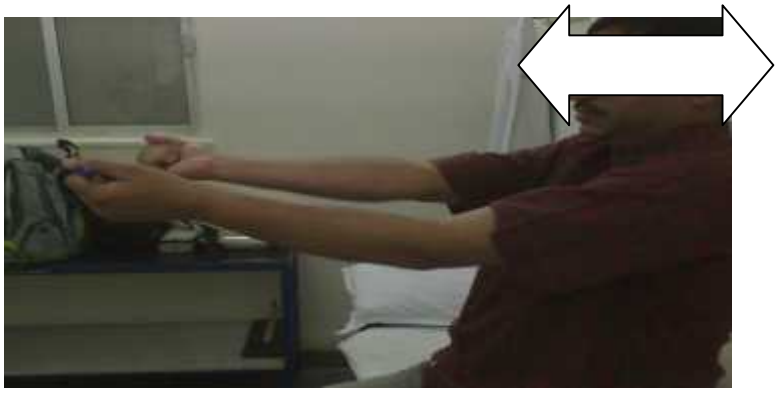
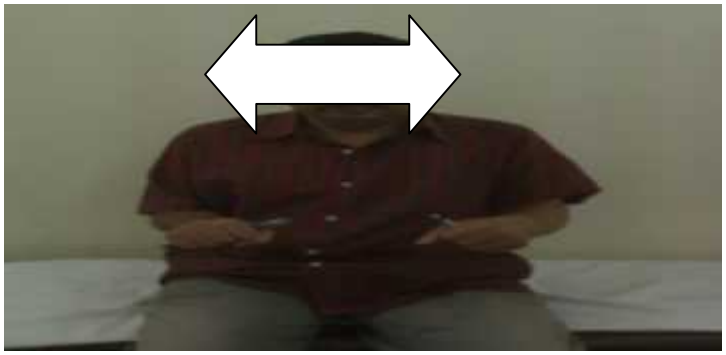


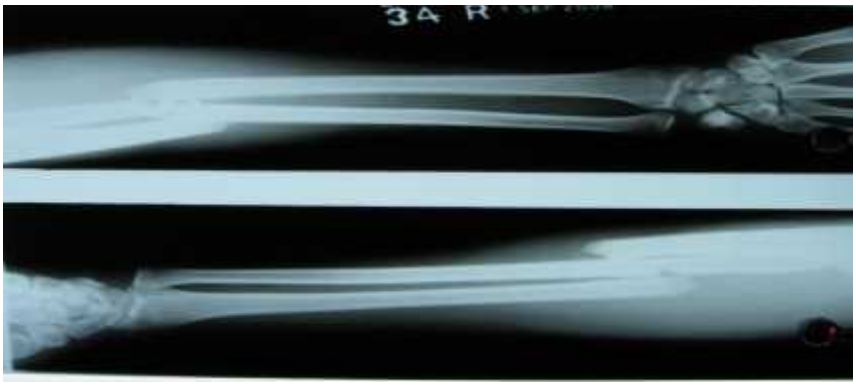
FULL EXTENSION

FULL SUPINATION



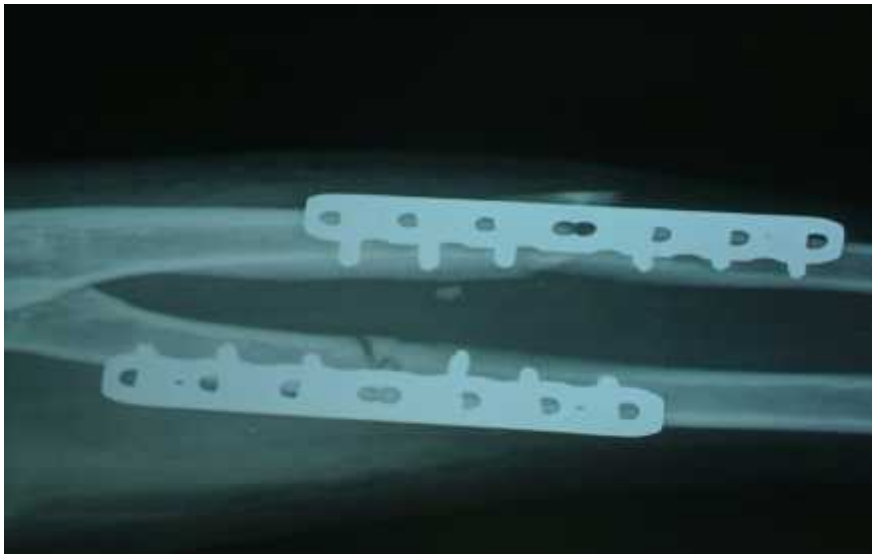
FULL PRONATION

GOOD RESULT



PREOPERATIVE X-RAY

POSTOPERATIVE X-RAY



FOLLOW UP X-RAY

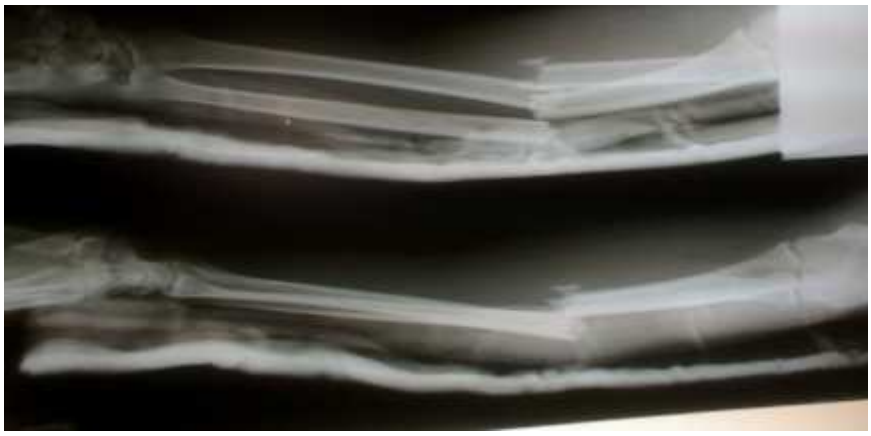
FULL FLEXION

FULL EXTENSION

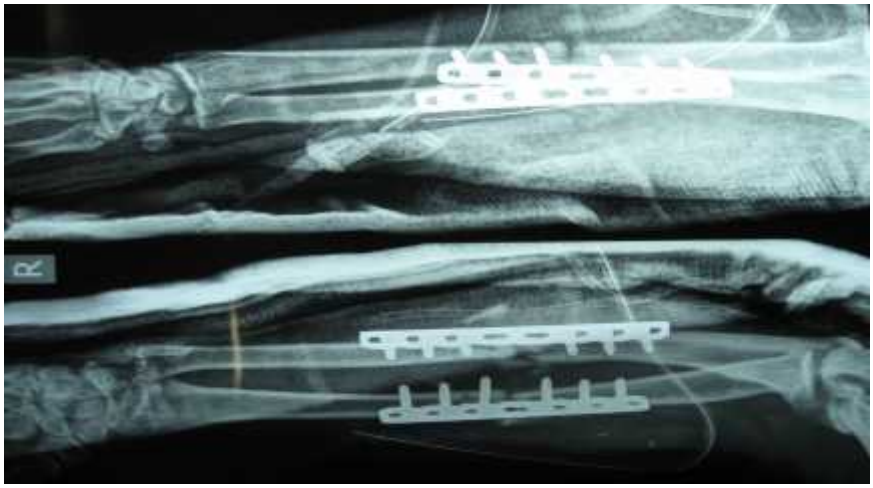
FULL SUPINATION

FULL PRONATION

FAIR RESULT



PRE OPERARIVE X-RAY



POSTOPERATIVE X-RAY

FOLLOW UP X-RAY

RESTRICTED FLEXION

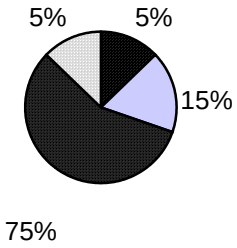
FULL EXTENSION

FULL SUPINATION

RESTRICTED PRONATION

CHARTS

Involved Bone Group A



BB- 15(75%)

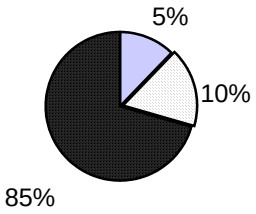
3 Isolated ulna- (15%)

1 Isolated radius-(5%)

1 Galeazzi - (5%)

Chart- 1

Involved Bone Group B



BB- 17 (85%)

2 Isolated ulna (10%)

1 Isolated radius(5%)

Chart-2

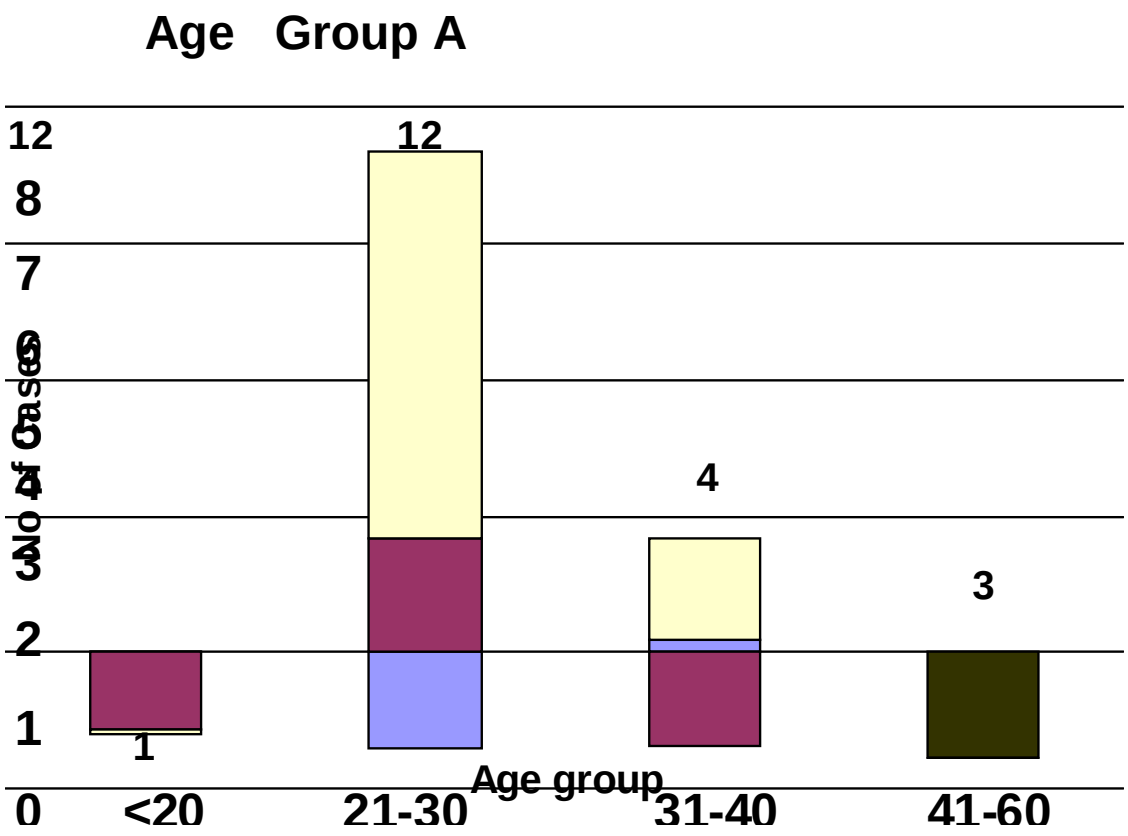


Chart-3

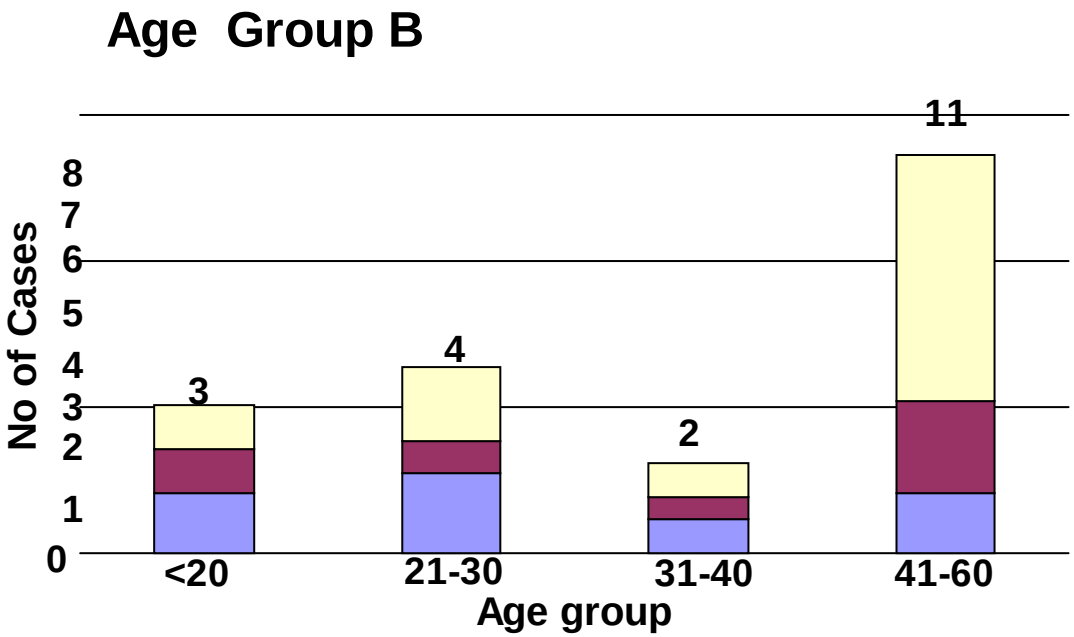
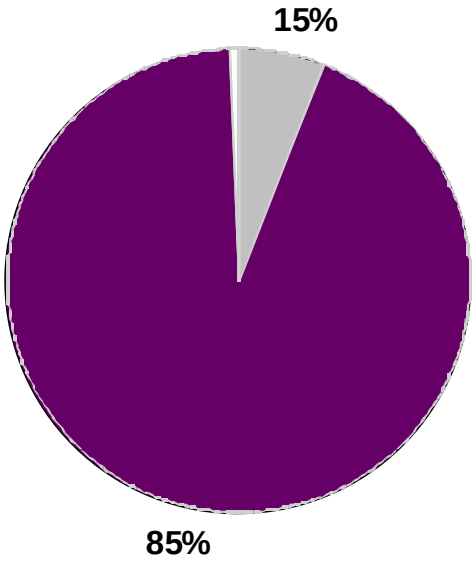


Chart-4

SEX GROUP- A

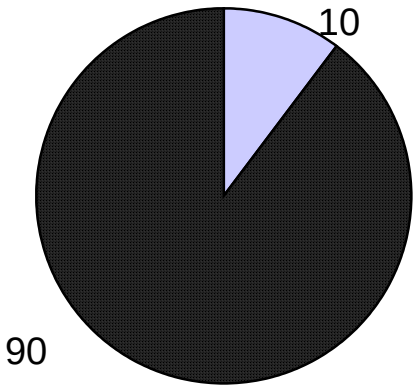


Males- 85%

Female-15%

Chart- 5

SEX- GROUP- B

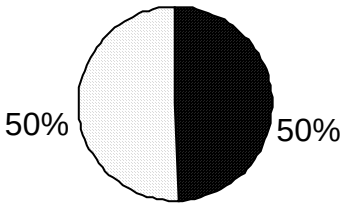


Males-90%

Female-10%

Chart-6

SIDE Group A

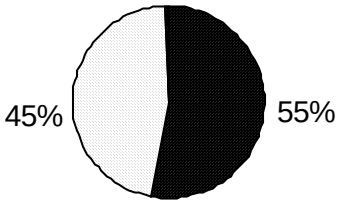


Right- 50%

Left- 50%

Chart-7

SIDE Group B



Right-55%

Left- 45%

Chart- 8

Mechanism of Injury Group A

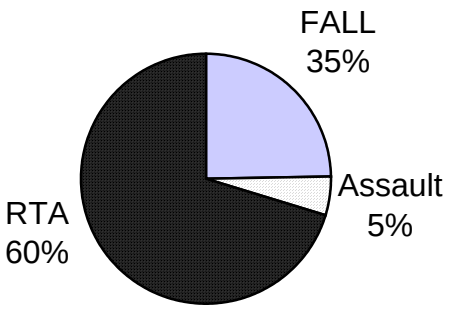


CHART-9

Mechanism of Injury Group B

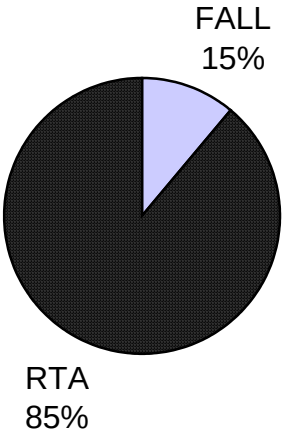
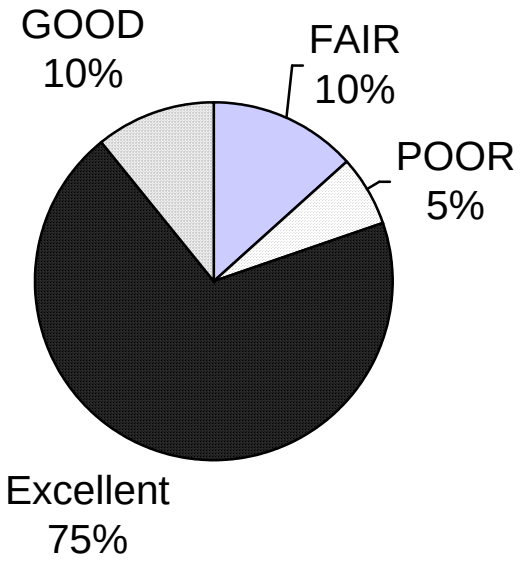
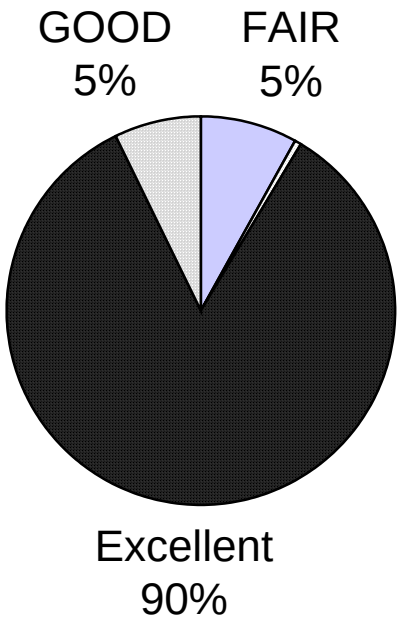


CHART-10

Results Group A CHART-11



Results Group B CHART-12



ANNEXURE ff - PROFORMA

1) NAME :

2) AGE:

3) SEX: M/F

4) ADDRESS:

5) OCCUPATION:

6) DATE OF INJURY:

7) DATE OF ADMISSION:

8) DATE OF SURGERY:

9) DATE OF DISCHARGE:

10) NATURE OF TRAUMA:

a) RTA Yes/No b) Sports injuries Yes/No

c) Fall from height Yes/No d) Assault Yes/No

e) Trivial injuries Yes/No f) other injuries Yes/No

11) MECHANISM OF INJURY:

a) Direct Yes/No b) Indirect Yes/No

12) DURATION SINCE INJURY:

a) < 1 week b) > 1 week

13) SIGNIFICANT PAST HISTORY :

a) History of Diabetes Yes/No

Hypertension Yes/No

Asthma Yes/No

Epilepsy Yes/No

Other Conditions Yes/No

b) Previous history of fractures Yes/No

14) SIGNIFICANT FAMILY HISTORY:

15) GENERAL PHYSICAL EXAMINATION :

a) Pulse rate ☐☐ ☐ b) Blood Pressure ☐ ☐/ ☐ ☐ ☐ ☐

c) Spo2 ☐ ☐ d) Respiratory Rate ☐ ☐

e) Pallor Yes/No

f) Cyanosis Yes/No

g) Icterus Yes/No

h) Lymphadenopathy Yes/No

i) RS examination:

j) CVS examination:

k) PA examination:

l) CNS examination:

m) Presence of associated injury : Yes /No if Yes, Specify

16) LOCAL EXAMINATION

INSPECTION	Rt	Lt
	Closed	Closed
	Open-GUSTILO/AO	Open-GUSTILO/AO
PALPATION -	SWELLING	Yes/No
	TENDERNESS	Yes/No
	CREPITUS	Yes/No
	ABNORMAL MOBILITY	Yes/No
	OTHERS	

17) RELEVANT INVESTIGATIONS **:** Yes/No

- X-Ray – Forearm (Full length)- AP, Lateral Yes/No
- Additional X-ray of associated injuries Yes/No
- Routine Blood investigations like Hb, TLC,DLC. Yes/No
- Renal Profile Yes/No
- HIV, HbSag, Yes/No
- Chest X-ray , ECG Yes/No

18) CLASSIFICATION:

AO TYPE :

TYPE –A-	$A_{1,}$	$A_{2,}$	A_3
TYPE –B-	$B_{1,}$	$B_{2,}$	B_3
TYPE –C-	$C_{1,}$	$C_{2,}$	C_3

19) DIAGNOSIS:

20) TREATMENT**:** Yes/No

First Aid : a) Immobilization of the limb Yes/No

b) Arm Sling / POP slab Yes/No

c) Analgesics Yes/No

Definitive Treatment **:**

a) Relevant investigations and medical fitness for surgery Yes/No

b) Anesthesia: GA / Brachial Block Yes/No

c) DCP / LCP Yes/No

d) Antibiotic therapy – preop and postop Yes/No

e) Analgesics Yes/No

21) COMPLICATIONS :

Intraoperative: a) Difficulty in reduction of fragments Yes/No

b) Excessive Bleeding Yes/No

c) Wrong Placement of Implant Yes/No

d) Other Complications Yes/No

Postoperative: A) Immediate :

a) Bleeding Yes/No

b) Infection Yes/No

B) Delayed :

a) Chronic Infection Yes/No

b) Posterior interosseous nerve palsy Yes/No

c) Loss of movement Yes/No

d) VIC Yes/No

e) Synostosis Yes/No

22) FOLLOW UP:

Date :

Serial No. of follow up:

Time since surgery:

Clinical Union:

- ► Pain at fracture site Yes/No
- ► Abnormal Mobility Yes/No

Radiological Union : X-Ray Yes/No

23) CRITERIA FOR EVALUATION OF RESULTS:

ANDERSON ET AL CRITERIA

1. EXCELLENT – UNOIN WITH <10° LOSS OF FLEXION/EXTENSION AND <25° LOSS OF PRONATION /SUPINATION.
2. GOOD – UNOIN WITH <20° LOSS OF FLEXION/EXTENSION AND <50° LOSS OF PRONATION /SUPINATION.
3. FAIR – UNION WITH > 20° LOSS OF FLEXION / EXTENSION WITH > 50° LOSS OF PRONATION /SUPINATION.
4. POOR – NON UNION WITH OR WITHOUT LOSS OF MOTION .

24) RESULTS **:**

1.EXCELLENT ☐

2.GOOD ☐

3.FAIR ☐

4.POOR ☐

INFORMED CONSENT

"A RANDOMIZED CONTROLLED STUDY OF DYNAMIC COMPRESSION PLATING (DCP) VERSUS LOCKING COMPRESSION PLATING (LCP) IN TREATMENT OF FOREARM BONE FRACTURES IN ADULTS (AGE 18-60 YEARS)."

PRINCIPLE INVESTIGATOR : BL0108002

INTRODUCTION AND PURPOSE :

DCP or LCP Plating has been used successfully in treating forearm bone fractures. This is an improved modality of treatment resulting in good post operative rehabilitation and excellent patient compliance .

PROCEDURE :

In this study you will be asked about the manner in which you got the injury, the present and past history and then after detailed clinical examination and investigations, you will be taken for required procedure with either LCP or DCP plating would be used. The plate is inserted by open technique. The patient will be followed up every second week till radiological union. The time taken for radiological and clinical union would be noted down. You will also be observed for any kind of complication and if present, it will be treated.

BENEFITS :

1. You will be getting an upcoming modality of treatment as part of the internationally accepted standards**.**

2. The results of the study may improve the treatment guidelines thereby benefiting other patients.

RISKS :

1. Difficulty in reduction.
2. Infection.
3. Posterior interosseous nerve palsy.
4. Loss of movement.

ALTERNATIVES :

If the patient is not ready to act as a participant, he/she will be provided with conventional modality of treatment.

VOLUNTARY PARTICIPATION/ WITHDRAWAL:

Taking part in study is voluntary. I may choose not to take part in this study, or if i decide to take part, I can later change my mind and withdraw from the study. My decision will not change the present or future health care or other services that i receive. The study doctor or the sponsorer may stop my participation in this study. If i choose not to take part in the study, I will receive the standard treatment for patients with my condition.

COSTS:

The cost for the patient for either LCP or DCP would come to around Rs 3000/- and 1000/- respectively, would be explained to the patient.

COMPENSATION:

In the event of any injury related to this study treatment, will be available through KLE Dr .PRABHAKAR KORE Hospital, but there will be no compensation for such medical treatment by law.

CONFIDENTIALITY:

All information collected about you during the course of the study will be kept confidential to the extent permitted by the law. Information from this study may be published, but your identity will be kept confidential in any publication. The results of this study would only be useful in patient care.

QUESTION:

In any enquiries in the future or in case of research related injury illness, you may contact the concerned person.

CONSENT FOR PARTICIPATION IN RESEARCH TRIAL:

I, Mr _____ voluntarily agree for the participation as a subject of study. By signing this consent form, I am not giving up any of my legal rights and i may withdraw from the study anytime. I am signing the consent form after having read or been read for me in vernacular language, including the risks and the benefits and having all my questions answered.

Subject Name : _____

Signature or the Left Thumb Print of Subject : _____

Witness Name**:** _____ Signature**:**_____

Investigators Name: _____ Signature: _____

Date : _____

Place : _____

ANNEXURE - IV
Master chart
Group A DCP

S NO	NAME	I.P NO	AGE	SEX	SIDE	TYPE OF #.	DOA	DOS	DOD	Mech of inj.	Plate size	Dur of surg.	APPROACH	ANEST	HOSP STAY.	ASSO INJURY	UNION(WK)	FolM	Result
1	Dimappa	318869	22	M	RT	C3	20/5/09	25/5/09	6/6/09	RTA	6 for BB	70	HEN	BR	16 DAYS	-	8	6	EXC
2	Dinesh	335647	23	M	RT	C3	18/9/08	19/9/08	1/10/08	RTA	8,7 R,U	100	HEN	GA	12 DAYS	-	9	10	EXC
3	Gopal	294235	19	M	LT	B3	2/9/08	4/9/08	15/9/08	Fall	6 for BB	80	HEN	GA	13 DAYS	-	12	6	Fair
4	govidappa	289768	23	M	RT	C3	2/2/09	3/2/09	14/2/09	Fall	7,6 R,U	120	THOM	GA	12 DAYS	-	14	8	GOOD
5	Hanumanth	292123	27	M	RT	C3	30/12/08	4/1/09	15/1/09	RTA	7 for BB	100	HEN	GA	16 DAYS	Head Inj	16	12	POOR.
6	Indrawa	284545	50	F	LT	C3	15/8/08	17/8/08	30/8/08	RTA	6 for BB	120	HEN	GA	15 DAYS	-	18	16	EXC
7	Jaipal	270110	25	M	LT	C3	2/9/08	3/9/08	15/9/08	Fall	7,6 BB	75	THOM	GA	13 DAYS	-	10	20	EXC
8	Kutubuddin	337639	58	M	RT	C3	9/10/09	10/10/09	20/10/09	RTA	8 for BB	145	HEN	GA	11 DAYS	Clw for.	18	10	GOOD
9	Linganagouda.	318301	58	M	LT	B1	18/5/09	21/5/09	1/6/09	Fall	8,6 R, U	80	HEN	BR	13 DAYS	-	12	13	EXC
10	Mahesh	322299	22	M	LT	C3	5/9/08	6/9/08	17/9/08	RTA	7,6 RU	100	DAU	GA	12 DAYS	-	16	12	EXC
11	Mehaboob.	352972	30	M	LT	C3	7/2/10	8/2/10	20/2/10	RTA	6 for BB	130	HEN	GA	13 DAYS	Clw scalp	22	6	Fair
12	Nagraj	350074	21	M	RT	C3	15/1/10	16/1/10	30/1/10	RTA	6 for BB	120	HEN	BR	15 DAYS	-	20	7	EXC
13	Rashid	330047	35	M	RT	C3	13/8/09	2/9/09	15/9/09	RTA	7 for BB	140	HEN	GA	32 DAYS	-	12	11	EXC
14	Veerappa.	301567	28	M	RT	A3	21/6/09	21/6/09	30/6/09	RTA	6 for BB	65	HEN	GA	9 DAYS	-	10	14	EXC
15	Vijay	323376	23	M	LT	B3	26/6/09	27/6/09	10/7/09	Assault	7,6 R,U	100	HEN	GA	14 DAYS	-	16	13	EXC
16	Prakash.	345135	31	M	LT	B1	5/12/09	6/12/09	12/12/09	RTA	7 for U	60	DAU	BR	7 DAYS	-	12	9	EXC
17	Chidanand.	359900	28	M	LT	B1	2/2/10	4/2/10	15/2/10	Fall	8 for U	50	DAU	BR	13 DAYS	-	12	6	EXC
18	maruti	365432	27	M	LT	A2	11/2/10	15/2/10	25/2/10	Fall	7 for R	40	THOM	BR	14 DAYS	-	10	6	EXC
19	Bismilla	366328	33	F	RT	C3	18/2/10	19/2/10	25/2/10	RTA	6,7 R,U	75	HEN	BR	7 DAYS	-	6	6	EXC
20	Veena	326776	32	F	RT	B3	4/8/09	5/8/09	20/8/09	Fall	7 for BB	90	THOM	GA	16 DAYS	L. con	14	6	EXC

KEY TO MASTER CHART:

DOA- Date of admission.
DOS- Date of surgery.
DOD-Date of discharge.
ANEST- Anesthesia.
FOL-Follow up.
Mech of Inj- Mechanism of injury.
BB-Both bone.
M-Male.
F-Female.
HEN- Henry's approach.
THOM-Thompson's approach.
DAU-Direct approach to ulna.
WK-Week ; M-Month
EXC-Excellent.

RT-Right. RTA-Road traffic accident.
LT-Left. R,U- Radius, Ulna
L..Con- Lung contusion.

MASTER CHART- GROUP-B LCP

S NO	NAME	I.P NO	AGE	SEX	SIDE	TYPE OF #.	DOA	DOS	DOD	Mech of inj.	Plate size	Dur of surg.	APPROACH	ANEST	HOSP STAY.	ASSO INJURY	UNION(WK)	FolM	Result
1	abisek	324389	20	M	RT	B3	21/8/09	22/8/09	2/9/09	RTA	7, 6 for R,U	120	HEN	GA	10 DAYS	-	8	12	EXC
2	rohesh	263266	30	M	RT	C3	18/9/08	19/9/08	1/10/08	RTA	8, 7 for R,U	100	HEN	GA	12 DAYS	Humerus shaft #	9	18	EXC
3	Juber	330476	48	M	LT	C3	17/8/09	22/8/09	2/9/09	RTA	7 for BB	80	HEN	BR	14 DAYS	-	7	12	EXC
4	karthik	220568	19	M	RT	C3	4/9/08	5/9/08	9/9/08	Fall	10 forU	50	DAU	BR	5 DAYS	-	9	6	EXC
5	pooja	298763	18	F	RT	C3	22/10/08	23/10/08	3/11/08	Fall	7 for BB	90	HEN	GA	11 DAYS	-	10	18	EXC
6	shipai	334289	35	M	RT	C3	13/8/09	21/8/09	1/9/09	RTA	7 for BB	150	THOM	GA	18 DAYS	-	9	10	EXC
7	sheetal	335061	28	M	RT	B3	20/9/09	24/9/09	3/10/09	RTA	6 for BB	80	HEN	BR	13 DAYS	-	7	9	EXC
8	Prostil	353300	29	M	RT	C2	10/2/10	11/2/10	15/2/10	RTA	7 for R	40	HEN	BR	5 DAYS	-	6	6	EXC
9	Shailendra.	334297	44	M	LT	C3	17/2/10	20/2/10	28/2/10	RTA	6,5 for R, U	90	HEN	BR	9 DAYS	-	8	6	EXC
10	Danraj	358198	37	M	LT	C1	20/2/10	23/2/10	1/3/10	RTA	6 for U	30	DAU	GA	9 DAYS	Humerus shaft #	12	6	GOOD
11	Somnigappa	362253	25	M	LT	C3	19/2/10	8/3/10	18/3/10	RTA	7,6 for R,U	75	THOM	BR	30 DAYS	L con.	8	6	Fair
12	Nagraj	220987	42	M	RT	C3	3/5/09	4/5/09	14/5/09	RTA	7 for BB	90	HEN	BR	10 DAYS	-	9	15	EXC
13	Dinesh	230022	48	M	RT	B3	9/9/09	10/9/09	20/9/09	RTA	7 for BB	80	THOM	GA	11 DAYS	-	10	11	EXC
14	Prema	230081	54	F	LT	B3	6/6/09	7/6/09	17/6/09	RTA	6 for BB	75	HEN	BR	11 DAYS	-	7	14	EXC
15	sankar	320989	50	M	LT	C1	18/2/10	20/2/10	28/2/10	RTA	7 for U	40	DUA	BR	10 DAYS	-	6	6	EXC
16	sanmuk	372352	41	M	LT	C3	28/2/10	28/2/10	8/3/10	RTA	7,6 forRU	70	THOM	BR	10 DAYS	-	8	6	EXC
17	Ravindra.	374513	48	M	RT	C3	13/2/10	14/2/10	23/2/10	RTA	7,8forRU	75	HEN	GA	10 DAYS	-	10	6	EXC
18	basavraj	374862	42	M	LT	C3	12/2/10	16/2/10	25/2/10	RTA	7 for BB	80	HEN	BR	12 DAYS	-	7	6	EXC
19	mallik	240466	56	M	RT	C3	3/4/09	4/4/09	12/4/09	Fall	7 for BB	110	THOM	BR	9 DAYS	-	4	16	EXC
20	Ashok	287455	52	M	LT	B3	5/5/09	6/5/09	15/5/09	RTA	7 for BB	120	HEN	GA	10 DAYS	-	12	14	EXC