"EXTERNAL FIXATOR AND K-WIRE FIXATION VERSUS LOCKING COMPRESSION PLATE IN MANAGEMENT OF DISTAL - END RADIUS FRACTURES FRYKMANN'S TYPE VII AND VIII" -- A RANDOMISED CONTROLLED TRIAL."

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ENDORSEMENT BY THE HOD, PRINCIPAL/ HEAD OF THE INSTITUTION

This is to certify that the dissertation entitled **"EXTERNAL FIXATOR AND K-WIRE FIXATION VERSUS LOCKING COMPRESSION PLATE IN MANAGEMENT OF DISTAL - END RADIUS FRACTURES FRYKMANN'S TYPE VII AND VIII" -- A RANDOMISED CONTROLLED TRIAL.",** is a bonafide research work done by **BL0108001**.

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ABSTRACT

BACKGROUND:

Distal end radial fractures represent approximately one-sixth of all fractures treated in emergency department. External fixator is based on ligamentotaxis and is unable to prevent dorsal collapse of the radius or maintain the normal palmar tilt of the radiocarpal joint surface. This complication may predispose to posttraumatic wrist instability and arthritis. Locking compression plate (LCP) is a new screw – plate system developed by combining the traditional plating techniques with the principles of AO internal fixator. The distal radius is the foundation of the wrist joint , reconstruction of articular congruity and stable fixation reduces the incidence of post-traumatic osteoarthritis and allows early Functional rehabilitation. The goal of the current study is to assess the efficacy of anatomical and functional outcome in patients treated with external fixator and k-wire fixation or locking compression plate.

MATERIALS AND METHODS:

A prospective study, including 30 cases done in December 2008 to July 2010. The cases were followed up for 6months at intervals of 6 weeks, 3 months and 6 months. The results were evaluated by assessing their clinical and functional outcome at follow-up as per Demerit scoring system.

All required routine investigations done pre-operatively. Study performed after obtaining consent of the patients. The Data analysis done for a period of 3 months using rates, ratios and Percentages of different outcomes as per Demerit scoring system , which will be computed and compiled.

RESULTS :

External fixator results : 2 patients achieved excellent , 8 patients had good, 3 fair results and 2 patients had poor results.LCP results: 3patients achieved excellent10 had good and 1achieved fair and 1 poor outcomes. No nonunion or infection occurred in present study.

CONCLUSIONS: locking compression plating is a superior, safe and effective treatment for unstable fractures of the distal radius, giving excellent results in younger individuals and elderly osteoporotic patients.

KEYWORDS: distalend radius fracture; external fixator; locking compression plate.

LIST OF ABBREVIATIONS USED

C V S	-	Cardio Vascular System
C N S	-	Central Nervous System
DOA	-	Date Of Admission
DOD	-	Date of Discharge
DOS	-	Date of Surgery
DOF	-	Duration of fixation
FFH	-	Fall from height
FOSH	-	Fall on out stretched hand
LCP	-	Locking compression plate
E.C.G	-	Electro-cardiogram
E S R	-	Erythrocyte Sedimentation Rate
Hb	-	Haemoglobin
HBsAg	-	Hepatitis B surface antigen
HIV	-	Human immunodeficiency virus
HTN	-	Hypertension
IP No.	-	Inpatient Number
I.V	-	Intravenous
L	-	Left
R	-	Right
ROM	-	Range of movement
R S	-	Respiratory System
RTA	-	Road traffic accidents
Sl No.	-	Serial Number

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INTRODUCTION

Distal end radial fractures represent approximately one-sixth of all fractures treated in emergency department.[1]

The goal of treatment is to restore congruity to the radiocarpal and distal radioulnar joint surfaces and to restore and maintain the length of the radius.

In current opinion in orthopaedics, a study concludes that external fixation appears to have benefits that outweigh associated complications and as such, make it an attractive treatment option for fractures of the distal radius that require surgical treatment. Both its ease of use and successful track record make it an extremely versatile tool for the treatment of these injuries.[2]

A study conducted in hongkong concludes that application of a locking compression plate for displaced distal radial fracture is a safe alternative. It provides stable fixation with excellent radiographic and functional results and minimal complications.[3]

The goal of the current study is to assess the efficacy of anatomical and functional outcome in patients treated with external fixator and k-wire fixation or locking compression plate.

Frykmann established the homogenous classification system, which specifies the intra articular or extra-articular nature of the fracture, the individual participation of radiocarpal radioulnar joints, in combination with the existence or not of ulna's styloid process.

External fixator is based on ligamentotaxis, in which the fracture fragments are moulded by traction forces across the ligaments. Despite acceptable healing and adequate anatomic results with external fixation but a high complication rate resulting from injury or treatment, with a significant correlation between complications and poor functional outcome. In addition, external fixation is unable to prevent dorsal collapse of the radius or maintain the normal palmar tilt of the radiocarpal joint surface. This complication may predispose to posttraumatic wrist instability and arthritis. The problems with external fixation have prompted a search for a better treatment option.

An internal fixator placed through limited incisions on the dorsal aspect of the radius and spanning the fracture site can, in theory, provide the benefits of external fixation without the associated morbidity, In addition, these internal devices theoretically act as a mechanical dorsal buttress that prevents dorsal collapse and loss of palmar tilt in a manner analogous to volar buttress plate. An internal fixator is a reasonable alternative to external fixation if it is biomechanically equivalent in maintaining distraction and withstanding applied loads.

The use of precontoured angular stable plate fixation is characterized by higher stability even in osteopenic bone and in altered bone architecture as it is seen in osteoporosis. These implants afford osseous fixation that allows early motion and rehabilitation. Also their precontoured shape maintains desirable patterns of alignment, congruency and inclination of the distal radius after corrective osteotomy because of their ability to ensure angular and axial stability. These properties reduce the probabilities of screw loosening and consequent loss of reduction.[4]

Locking compression plate (LCP) is a new screw – plate system developed by combining the traditional plating techniques with the principles of AO internal fixator. The distal radius is the foundation of the wrist joint and an indispensable part of ligamentous support, reconstruction of articular congruity and stable fixation reduces the incidence of post-traumatic osteoarthritis and allows early Functional rehabilitation.[5]

LCP omits pre – bending, large area of exposure of fracture site, minimises soft tissue damage, significantly reduces non – union, infection and implant failure.

OBJECTIVES

1. To study the efficacy of external fixator and k-wire fixation versus locking compression plate in treatment of distal end radial fractures.

2. To study the anatomical outcome by radiographs.

3. To study the functional outcome in terms of pain, disability, range of movements.

REVIEW OF LITERATURE

HISTORICAL ASPECTS AND REVIEW OF LITERATURE

Fractures of the distal end radius were not recognised until beginning of 18^{th} century "Petit" was the first person to describe these fractures.

Ever since Abraham Colle's published "on the fracture of the carpal extremity of the radius in Edinburg medical journal(1814).His description of the fracture "this fracture takes place at about an inch and half above the carpal extremity of the radius & exhibits the following appearances. The posterior surface of the limb presents a considerable deformity, for a depression is seen in the forearm about an inch and half above this bone, while considerable swelling occupies the wrist & metacarpus. Indeed the carpus and base of the metacarpus appear to be thrown backwards so much as on first view to excite a suspicion that the carpus has been dislocated forward. On viewing the anterior surface of the limb, we observe considerable fullness, as if caused by the flexor tendons being thrown forwards. This fullness extends upwards to about the third of the length of the length of the forearm and terminates below, at the upper edge of the annular ligament of the wrist. The extremity of the ulna is seen projecting towards the palm and inner edge of the limb, the degree however in which this projection takes place is different instances. If the surgeon proceeds to investigate the nature of this injury he will find the end of ulna admits of being readily moved backwards and forwards".

Until late 1920's principal treatment of Colle's fracture was forceful traction, manipulation, immobilisation in wrist dorsiflexion and ulnar deviation.

REVIEW OF LITERATURE – EXTERNAL FIXATOR

The origin of external fixation goes back to Malgaigne [1853-54], who in the 19th century developed strapped on metal points and claws to stabilize the displaced Fractures.

Park Hill [1898] of Denver and Lambotte [1907] of Brussels built the first clinically useful external fixators around the turn of century.

In 1929, Bohler was the first one to publish his technique of trans fixation with skeletal pins and incorporation in plaster cast to maintain the reduction of fracture, the so called "pin and plaster method" and showed significantly better results. The basic principle being to provide fixed traction, which maintains length of the radius.

About 1930, Anderson and O'Neil described utilization of an externally placed bar attached to bone via pins proximally and distally to the fracture. This simple external fixator has endured in various forms as a means of neutralizing the forces that otherwise lead to shortening of the distal radius after reduction.

In 1938 Raoul Hoffmann, devised a half frame external fixator, consisting of two ball joint clamps connecting the adjustable external bar of the fixator to strong pin gripping clamps.

In 1944 Roger Anderson who described the prototype of today's external fixator for treatment of communited fractures of distal end of radius.

After World War II, Ilizarov a Russian doctor developed a highly complex but versatile ring fixator, which could correct mal-alignment and shortening after corticotomy.

In 1979 – Grana W.A and Kopta J.[18] used the Roger-Anderson device in the treatment of distal radius fractures and had 80 % excellent and good results. They however advised to avoid external fixation in the older, obese and osteoporotic patients. They also avoided its use in non-cooperative patients.

In 1979- Cooney WP[12] got good results in 85% of patients with the use of 4 pins. They felt that 4 pins gave better fixation and pin loosening was less when compared with 2 pins.

In 1981-Van Der Linden, Ericson R.[19] concluded that displacement can be described adequately with only two measurements, one for dorsal and other for radial displacement. The technique of immobilization did not influence the final results.

1983 – Cooney WP[17] analysed the results with four different external fixation devices in a consecutive series of 100 unstable distal radial end fractures and opined that quadrilateral frame fixation provided effective immobilization and produced good to excellent results in 86 % of patients.

In 1985 – Basset RL[20] emphasized on anatomical reduction and sufficient distraction with external fixators in managing distal end of radius fractures.

1985 – Vaughan PA[21] used Roger Anderson external fixator in the treatment of unstable fractures of distal radius in 52 patients and the results were evaluated after a follow up averaging 58 months. They had 89 % good or excellent and 11 % fair results. There were no poor results. 14 % developed complications.

1986 – Jupiter JB, Knirk JL[22] reported that when an external fixator was used without bone grafting there was often collapse at the fracture site, especially for severely comminuted fractures. Hence they advised primary bone grafting along with ligamentotaxis.

1987 – Foster DE, Kopta JA[23] provided an update on external fixators in the treatment of wrist fractures. They did not find any significant difference in the functional results obtained with Roger Anderson or Hoffmann C - series external fixator.

1987 – Villar RM[24] pointed out the importance of radial shortening as an important feature most likely to influence the outcome, particularly in terms of grip strength.

1987 – Jenkins NH[25] conducted a prospective controlled study of 58 patients under the age of 60 years with Colle’s fracture. They were treated either with Forearm plaster or by the application of external fixation. They opined that external fixator was more effective at holding the manipulated position when compared to plaster application.

1989 – Kogsholm J, Olerud C[26] compared 75 patients with Frykman type VIII fractures of distal radius treated by primary external fixation and closed reduction. They concluded that all the fractures treated with external fixation remained well reduced and aligned, whereas 88 % of these treated with cast had unsatisfactory alignment. The external fixator group also had superior results with respect to functional outcome, range of motion and grip strength.

1989 – Leung K S[27] advised distraction, external fixation and bone grafting as an excellent method of treating comminuted fractures of distal radius.

1990 – Seitz W H[28] concluded that 4 mm self tapping pins results in a significantly higher pull out strength and only a small decrease in torsional load strength of bone.

1991 Jakim I, Pieterse, Sweet MBE[29] had 83 % good or excellent results with external fixators.

1992 Edward G S[30] treated 30 adults with severely comminuted fractures by closed reduction and AO external fixators and got excellent results. They attributed it to superior design of AO fixators.

1994 – Sommer Kamp T G[31] did a prospective randomized study comparing dynamic external fixators with static external fixators. They did not support the concept of early mobilization with a dynamic fixator, because of subsequent significant loss of reduction and lack of a demonstrable improvement in the mobility or the overall function of the wrist.

1998 – McQueen M M[32], carried out a randomized prospective study on 60 patients with unstable fractures of distal radius to compare bridging with non-bridging external fixation using pins placed in the distal fragment of the radius and they concluded that non bridging external fixation is the treatment of choice. Non bridging external fixation avoids the need to depend upon ligamentotaxis which does not restore volar tilt with any degree of certainty.

2000 – Harish Kapoor, Ashoo Agarwal & B. K. Dhaon[33] carried out a comparative evaluation of results following closed reduction, external fixators and open reduction internal fixation. 90 adult cases of acute displaced intra-articular fractures of lower end of radius were classified according to Frykman's classification & AO classification. These were randomly treated by one of three methods.

(1) Closed reduction with casting.

(2) External Fixation.

(3) Open reduction with internal fixation. They were followed upto 4 years.

In the final functional assessment the results were.

a) Closed reduction with casting gave 43 % good and excellent, 50% fair, 7% Poor results.

b) External fixation gave 80 % good and excellent results, 20% fair and poor results.

c) Open reduction and internal fixation gave 63 % good and excellent results, 20 % fair and 11% poor results. The authors recommended, intra articular displaced fractures should be treated with external fixation.

2000 – Douglas T. Hutchison[34] did a study whether to predrill or not to predrill. Their clinical study included 50 consecutive External fixators [4 & 2.5 mm pins] using 100 predrilled and 100 direct drilled pins placed in a randomized manner. There was no increased incidence of pin track infection or other pin problem with the direct drilled technique. There were, however, significantly elevated temperatures with the direct drilled technique. They therefore recommend, predrilling even though the temperature difference in this bone with that fixator were not clinically evident.

2003 – J. Krishnan[35] did a prospective randomised controlled trial comparing static bridging and dynamic non – bridging external fixation in distal end, intra articular fractures of radius. Their results did not demonstrate a statistically significant difference in the radiological and clinical outcome achieved by these two treatment methods.

2004 –Nagi O. N, Dhillon MS[36] did a prospective study using external fixators in 35 patients with distal, intra articular fractures of radius and kept them in 17 patients for 8 weeks and in 18 patients for 5 weeks and compared the anatomical and functional results at 6 months. There was no statistically significant difference in the clinical or radiological results in these 2 group of patients. Hence the authors recommend that the fixator be kept for a period of 5 weeks as no additional advantage is gained after fixator use for longer periods.

2004 – Brain J Harley[37] carried out a prospective randomized trial between Augmented external fixation versus percutaneous pinning and casting. 50 patients less than 65 years of age were considered in whom over 80 % of the fractures were classified as AO-ASIF C2 or C3. They concluded that although augmented External fixation represents a popular first line treatment for these fractures, similar results can be obtained with percutaneous pins and casting.

2004 – Anurag Aggarwal[38] carried out a prospective study between bridging and non-bridging fixator. They concluded that non bridging frame is better than bridging ones in selected cases of intra articular fractures of distal end of radius.

REVIEW OF LITERATURE – LOCKING COMPRESSION PLATE

In 1965 Ellis was one of the earliest to recommend open reduction and internal fixation of the unstable Smith's fracture or volar Barton fracture. He devised a T-plate which acted as an excellent volar buttress preventing the deformity.

In 1987 Clyburn described a new dynamic external fixator that allows controlled wrist movements and full movements of the fingers. This early wrist mobilisation facilitates early rehabilitation and excellent results.

In 1993 Cooney and Berger a more aggressive approach of open reduction internal fixation & external fixation with bone grafting in most high energy distal radius intra-articular fractures

In 1995 Mc Birnie & Mcqueen revised a new method of open reduction, bone grafting and fixation with k-wires.

In case of complex or multi-fragmentary fractures, where external fixation fails to provide support, use of internal fixation devices becomes necessary for bone healing.

Internal fixation devices share the load with the bone and support it until it is fully healed or can be kept during the entire lifetime of the recipient. Today, there are many types of internal fixation devices available and one can be used depending on the application.

In early days, the main goal of these devices was to achieve the stable fixation by mean of fracture compression. In this type of osteosynthesis, screws are advanced in to the bone along a drilled and threaded pilot hole.

Compression plating technique had many disadvantages such as, vascular damage of the soft tissues, pre-contouring of the plate to match the anatomy of the bone and screw toggling. Gradual development in plating techniques led towards overcoming all these shortcomings of conventional plating technique and incorporating the most advanced technologies in fracture fixation in to a single internal fixation device, which is “Locking Compression Plate”.

Locking Compression Plate

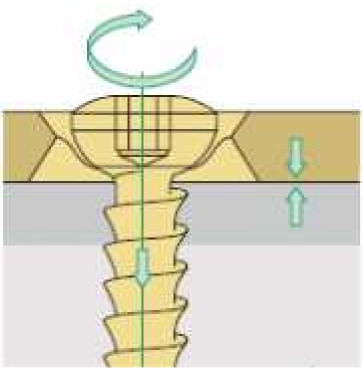
Evolution of LCP

In 1949, Danis designed the plate that he called ‘Coapteur’ which influenced all subsequent plate designs. It was designed to provide fixation with compression[39(7)].

Based on this compression technique, Schenk Willengegger developed the Dynamic Compression Plate (DCP). Even though DCP proved to be a better alternative to any of the previous plate designs, it required many improvements.

Dynamic Compression Plate (DCP), Non-locked plate osteosynthesis depends on the friction generated between the plate and the bone. As the screw head forces the plate onto the bone, potential energy converted to friction between the plate and the bone.

Fig: 1 Friction between plate and the bone



This friction creates a load transfer path from the bone to the plate, across the fracture area and back to the bone again.

As long as the frictional force exceeds the applied load, the construct remains stable. If the applied load exceeds the frictional force, it causes the screws to begin to toggle. Construct instability starts with screw toggling.

DCP did not provide enough rigidity and also, one of the major problems with this type of technique was preservation of blood supply. In order to overcome the problem with the interrupted blood supply, PC-Fix plates were designed. These plates, because of its design, allowed only points of the plate to be in contact with bone and thus helped reduce vascular damage.[40,41] Later on, so called locked internal fixators (PC fix) were developed which consisted of plate and screw systems where the screws are locked in the plate. This minimized the compressive forces exerted by the plate on to the bone.[41] The contact area was reduced down to point contact as shown in Figure 2(a).

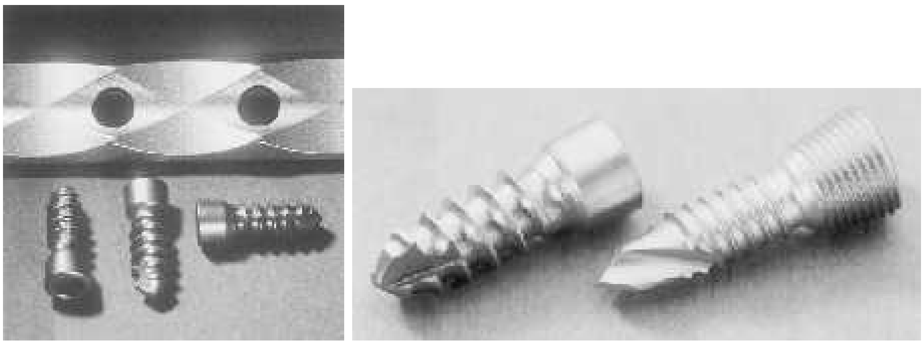


Fig. 2 (a) Under surface of a PC-Fix plate with point-shaped elevations (b) Left: First generation PC-Fix screw; Right: Second generation PC-Fix screw.

After PC-Fix, PC-Fix2 was developed which also provided axial stability of the screws along with the angular stability. This was achieved by machining a conical thread in both the screw head and the plate hole. Additional improvement was achieved by creating a new generation of PC-Fix screws with self-drilling and self-tapping tip as shown in Figure 2(b).

This can be helpful as screw track in the bone is no longer needed to be prepared with drill or tap. With PC-fix device, screws could only be inserted perpendicular to the plate which made it difficult to keep the bone fragments together when away from the plate. Thus, it failed to fully achieve stable fixation and anatomic reduction.

In 1990, a group of doctors from Davos of Switzerland developed the **Locking Compression Plate** with combined concept of DCP, PC-Fix and LISS (Less Invasive Stabilization System) plate.[40,41(8,9)] The locking head screw is captured in the threaded part of the combination hole through more than 200 degrees. This provided angular as well as axial stability of the screw in the plate.

Fig:3 Locking Compression Plate

Locking Compression Plate (LCP) is a result of the multilateral collaboration of clinicians, researchers, developers and industry. Locking compression plate has a combination hole system (locking and non locking) which can accommodate both locking and non-locking screws.

According to AO (Arbeitsgemeinschaft Osteosunthesetragen) principle, any fracture fixation technique should fulfil following four conditions in order to be considered as a successful fixation device.

These conditions include:

1. Anatomic reduction,
2. Stable fixation,
3. Preservation of blood supply
4. Early mobilization.

Locking compression plate follows all of these principles as shown in the Figure:4

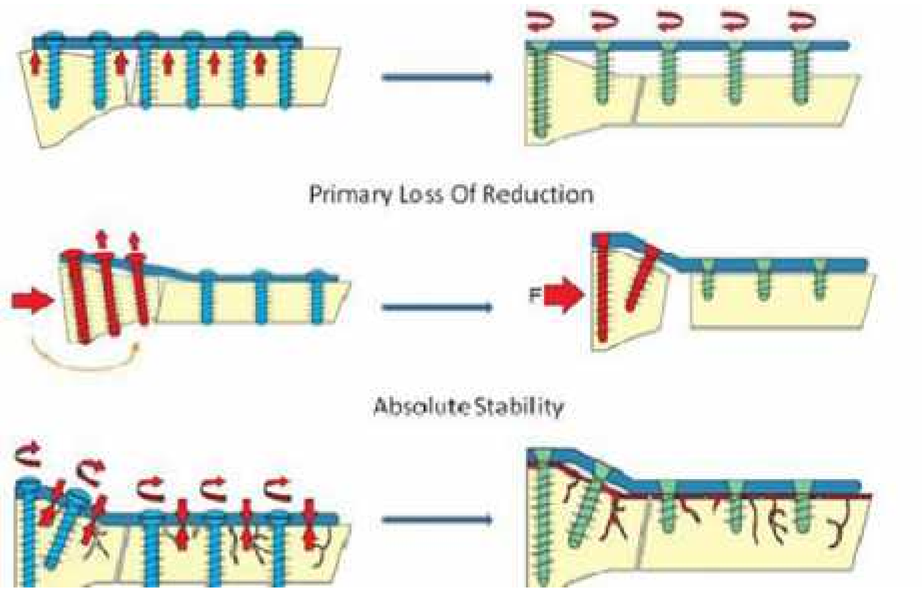


Fig:4 Locking compression plate fulfilling AO principles

1. Anatomic reduction

Fixation device should not affect the anatomic structure of the bone by creating unnecessary loads or friction and also help progress the fracture healing by osteosynthesis.

2. Stable fixation

While attached to the bone, fixation should provide both angular stability and axial stability against external loads and movements.

3. Preservation of blood supply

Plate to bone contact area should be kept minimal in order not to interrupt the blood supply to the tissue underneath the plate.

4. Early mobilization

It must create required local mechanical environment to regain the original bone structure as early as possible without the possible inflammation or non-union. Locking compression plates allow screws to be inserted perpendicular to the plate axis and thus it transmits the axial load over the length of the plate. This minimizes screw toggling and provides angular stability. Also, it is a point contact fixation system and thus it does not compress the plate to the bone and preserves the blood supply. Fixed angle construct and hybrid hole technique help in early callus formation and creates an environment suitable for bone healing and early mobilization.

Locking Plate Technology and Osteoporotic Bone:

The fracture healing process is different in the case of osteoporotic bone compared to the normal bone but the mechanism of fracture healing in osteoporotic bone is not yet clearly identified. Locking compression plate does not rely on the holding power of the screw for construct stability, providing successful fixation of an osteoporotic bone.

Conventional plating has a high failure rate in osteoporotic bone, classically seen with sequential screw loosening and migration. The thinner cortical bone in elderly also offers low resistance to pull out and toggle even if initial fixation is obtained. Locked plates as the screws are locked in to plate, cannot fail at the individual screw-bone interface level as all the screws have to pull out together with the plate. One more advantage is the smaller pitch of the screws which allows more threads to grasp the inner cortices.

It also has a unicortical fixation option:

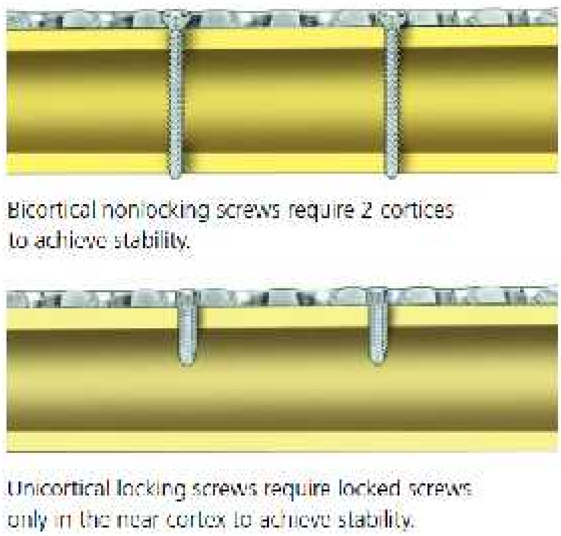


Fig:5 Bicortical fixation in non locked plates above and unicortical fixation below in locked plates

Unicortical locking screws provide stability and load transfer only at the near cortex due to threaded connection between the plate and screws. Because the screw is locked to the plate, fixation does not rely solely on the pullout strength of the screw or on frictional force between the plate and the bone.

Locking compression plate shows significantly high load at failure compared to standard plating technique for lower bone mineral densities. For higher BMD values there is not a significant difference in load to failure values, in fact these values are lower for LCP compared to standard plates. This shows that it is not cost effective to use LCP over standard plate for normal bone. But it is extremely advantageous for osteoporotic fractures.

In 2000- Kapoor and co-workers concluded that open reduction and internal fixation provide the best articular anatomy in highly comminuted fractures.

In 2005-wright et al concluded, the use of ORIF with a volar fixed-angle implant resulted in stable fixation of the distal articular fragments, allowing early postsurgical wrist motion

In 2006-Manfred Infanger et al carried out a study. The combination of minimal invasive reduction and stable internal fixation with preservation of the dorsal soft tissues resulted in rapid healing, no need for bone grafting and no incidence of tendon problems in our study in young patients.

2008- Antonio Abramo et al an RCT of 50 patients Internal fixation gave better grip strength and a better range of motion at 1 year, and tended to have less malunions than external fixation.

2008- In a recent study by Leung et al, a better result was found for internal fixation with AO plates either dorsally or volarly compared to bridging external fixation with augmentation with Kirschner wires.

ANATOMY OF THE WRIST

The Bones :

The Distal end of Radius :

The distal end of Radius, is the widest part, is four sided in section. Its lateral surface is slightly rough, projecting distally as a styloid process palpable when tendons around it are slack. Distal, is the smooth carpal articular surface, divided by a ridge into medial and lateral areas, the medial quadrangular, the lateral triangular and curving on to the styloid process.

The anterior surface is a thick, prominent ridge, palpable even though overlying tendons, 2 cm proximal to the thenar eminance.

The medial surface is the ulnar notch, smooth, antero-posteriorly concave for articulation with the ulnar head.

The posterior surface displays a palpable dorsal tubercle (Lister’s tubercle), limited medially by an oblique groove and in the line with the cleft between the index and middle finger. A wide, shallow groove, lateral to it, is divided by a faint vertical ridge. A similar but undivided groove is medial to the tubercle.

The radial styloid process projects beyond that of the ulna, its apex concealed by tendons of the abductor pollicis longus and extensor pollicis brevis. The carpal lateral ligament is attached to its tip. The lateral surface, near the styloid, receives the brachioradialis and is crossed obliquely, down and forwards, by tendons of the abductor pollicis longus and extensor pollicis brevis.

The terminal ridge on the anterior surface of the lower end is an attachment for the palmar radiocarpal ligament. To a smooth ridge distal to the ulnar notch the base of the triangular articular disc of the inferior radio-ulnar joint is attached. From the latter, a narrow protrusion of synovial membrane extends proximally anterior to the lower end of the interosseous membrane.

The lateral part of the carpal articular surface joins with the scaphoid and the medial part of the surface with the lateral part of the lunate bone; in full adduction the latter's proximal surface is wholly in contact with the radius.

The radial dorsal tubercle receives a slip from the extensor retinaculum and is grooved medially by the tendon of the extensor pollicis longus. The wide groove lateral to the tubercle contains tendons of the extensor carpi radialis longus laterally, extensor carpi radialis brevis medially and their synovial sheaths. Medially the dorsal surface is grooved by the tendons of extensor digitorum, but extensor indicis and the posterior interosseous nerve separate these from the bone. Attached to the distal margin of this surface is the dorsal radiocarpal ligament.

Ossification

The radius ossifies at three centers, in the shaft, appearing centrally in the eight week and in each end. Near the end of the first postnatal year ossification begins in the distal epiphysis, and in the proximal at the fourth year in females, fifth in males. The proximal fuses in the fourteenth year in females seventeenth in males, the distal in the 17th and 19th years respectively. A fourth centre sometimes appears in the tuberosity about the 14th or 15th year.

DISTAL END OF ULNA

The distal end, is a little expanded, has a head and styloid process. The ulna head is visible in pronation on the postero-medial carpal aspect and can be gripped when the supinated hand is flexed. Its lateral convex articular surface fits the radio ulnar notch. Its smooth distal surface is separated from the carpus by an articular disc, the apex of which is attached to a rough area between the articular surface and styloid process. The latter, a short, round, postero-lateral projection of the ulna's distal end, is palpable (most readily in supination) about 1 cm proximal to the plane of the radial styloid. A dorsal vertical groove is present between the head and styloid process.

Ossification

The ulna ossifies from 4 main centres, one each in the shaft and distal end and two in the olecranon. Ossification begins in mid-shaft about the eighth fetal week, extending rapidly. In the fifth (females) and sixth (males) years a centre appears in the distal end, extending into the styloid process. The distal olecranon is ossified as an extension from the shaft, the remainder from two centres, one for the proximal trochlear surface, and a thin scale-like proximal epiphysis on its summit.

The latter appears in the ninth year in females, eleventh in males ; the whole proximal epiphysis has joined the shaft by the 14th year in females, 16th in males. The distal epiphysis unites with the shaft in the 17th year in females, 18th in males.

The Carpal bones :

The carpus contains 8 bones in proximal and distal rows. Proximally, in lateral to medial border, are the scaphoid, lunate, triquetral and pisiform bones; in the distal row are the trapezium, trapezoid, capitate and hamate bones. The pisiform articulates with the palmar surface of the triquetral, thus separated from other carpal bones, all of which articulate with their neighbours. The other three proximal bones form on arch proximally convex, articulating with the radius and articular disc of the inferior radio-ulnar joint. The arch's concavity is a distal recess embracing, proximally, the projecting aspects of capitate and hamate bones; the two rows are thus mutually and firmly adapted without any loss of movement.

The dorsal carpal surface is convex and the palmar forms a deeply concave carpal groove, accentuated by the palmar projection of the lateral and medial borders. The medial projection is formed by the pisiform bone and the hamulus, an unciform palmar process of the hamate bone. The pisiform is at the proximal border of the hypothenar eminence, medial in the palm; it is easily felt in front of the triquetral. The hamulus is concave laterally, its tip palpable 2.5 cm distal to the pisiform, in line with the radial border of the ring finger.

The ulnar nerve's superficial division can be rolled on it. The lateral border of the carpal groove is formed by the tubercles of the seaphoid and trapezium. The former is distal on the anterior scaphoid surface and palpable, sometimes also visible, as a small medial knob at the proximal border of the palmar thenar eminence, lateral to the tendon of the flexor carpi radialis.

The trapezial tubercle is a vertically rounded ridge on the bone's anterior surface, slightly hollow medially and just distal and lateral to the scaphoid tubercle; it is difficult to palpate.

The carpal groove is made into on osseofibrous CARPAL TUNNEL by a fibrous retinaculum attached to its margin; the tunnel carries flexor tendons and the median nerve into the hand. The retinaculum strengthens the carpus and augments flexor efficiency. Palmar and dorsal surfaces of carpal bones, apart from the triquetral and pisiform, are attachments of the radiocarpal, intercarpal and carpometacorpal ligaments.

THE DISTAL RADIO ULNAR JOINT

This is a uniaxial pivot between the ulna’s convex distal end (head) and the concave ulnar notch of the radius ; these surfaces are enclosed by a capsule and connected by an articular disc. The fibrous capsule is thicker in front and behind, proximally lax and lined by synovial membrane projecting proximally between radius and ulna as a recesses sacciformis in front of the distal part of the interosseous membrane.

The articular disc is fibrocartilaginous (Collagen and elastic fibres in the young) and is triangular, binding the distal ends of ulna and radius. Its periphery is thicker, its center sometimes perforated. It is attached by a blunt, thick apex to a depression between the ulnar styloid process and distal articular surface and by its wider thin base to the prominent edge between the ulnar notch and carpal articular surface of the radius. Its margins are united to adjacent carpal ligaments, its surfaces smooth and concave; The proximal articulates with the ulnar head, the distal is part of the radiocarpal joint, articulating with the lunate bone and when the hand is adducted, the triquetral.

Movements

Pronation :

The muscles producing pronation is pronator quadratus (mainly), aided during rapid movement and against resistance by pronator teres. Gravity also assists.

Supination :

Supinator, in slow unassisted movements and biceps in fast movements with the elbow flexed especially when the resistance is encountered.

THE RADIOCARPAL JOINT

The radiocarpal joint, biaxial and ellipsoid, is formed by articulation of the distal end of radius and the triangular articular disc with the scaphoid, lunate and triquetral bones. The radial articular surface and distal discal surface form an almost elliptical, concave surface with a transverse long axis ; but the radial surface is bisected by a low ridge into two concavities. A similar ridge usually appears between the medial radial concavity and the concave distal discal surface. Proximal articular surfaces of scaphoid, lunate and triquetral bones and their interosseous ligaments form a smooth convex surface, received into the proximal concavity. Surface projection of the joint is a line, convex upwards, joining radial and ulnar styloid processes.

The articular surface is lined by synovial membrane which is usually separate from that of the inferior radio – ulnar and intercarpal joints; but a protruding prestyloid recess, ventral to the articular disc, is present and ascents close to the styloid process. The recess is bounded distally by a fibrocartilagenous meniscus, projecting from the ulnar collateral ligament between the tip of the ulnar styloid process and the triquetral; both are clothed with hyaline articular cartilage. The meniscus may ossify. The capsule is strengthened by palmar radiocarpal and ulnocarpal, dorsal radiocarpal and radial and ulnar collateral ligaments.

The Palmar Radiocarpal Ligament, a broad membranous band, is attached to the anterior margin of the distal end of the radius and its styloid process, its fibres passing distomedially to the anterior surfaces of scaphoid, lunate and triquetral bones, some reaching the capitate, it is partly intracapsular.

The Palmar Ulnocarpal Ligament is a rounded fasciculus from the base of the ulnar styloid process and anterior margin of the articular disc to the lunate and triquetral bones. Lewis et al and Mayfield et al regard both palmar carpal ligaments as intracapsular ; the latter also divide the radio carpal ligaments into 3 parts and ulno carpal ligament into 2 parts each named by its attachments. The palmar carpal ligaments are perforated by vessels and are related anteriorly to tendons of flexors digitorum profundus and pollicis longus.

The Dorsal Radiocarpal Ligament, thinner than the palmar, is attached to the posterior border of the distal end of the radius, its fibres descending distomedially to the dorsal surfaces of scaphoid, lunate and triquetral bones and continuing into the dorsal intercarpal ligaments. It is related posteriorly to the carpal and digital extensor tendons, their synovial sheaths and the posterior interosseous nerve; anteriorly it is blended with the disc of the distal radio-ulna articulation.

The Ulnar Collateral Carpal Ligament is attached to the apex of the ulnar styloid process; it divides into two fasciculi, one attached to the medial side of the triquetral, the other to the pisiform bone.

The Radial Collateral Carpal Ligament extends from the tip of the radial styloid process to the radial side of the scaphoid bone; some fibres are prolonged to the trapezium. It is related to the radial artery, curving round laterally between the ligament and tendons of abductor pollicis longus and extensor pollicis brevis. Both collateral ligaments are relatively weak.

MOVEMENTS:

Flexion : Muscles responsible

Flexor carpi ulnaris.

Flexor carpi radialis

Palmaris longus.

Assisted by :

Flexor digitorum superficialis

Flexor digitorum profundus.

Abductor pollicis longus.

Extension :

Extensor digitorum.

Extensor digiti miinimi.

Extensor indices.

Extensor pollicis longus.

Adduction : Flexor carpi ulnaris

Extensor carpi ulnaris.

Abduction : Flexor carpi radialis.

Extensor carpi radialis longus and brevis.

Abductor pollicis longus and extensor pollicis brevis.

BLOOD SUPPLY TO THE DISTAL RADIUS

Blood supply to the distal radius is mainly from the anterior interosseous artery and radial artery.

The ulnar artery and the posterior interosseous artery are involved indirectly via the anastomoses between the carpal arteries.

The vascularity arises from :

a) Nutrient arteries.

b) Metaphyseal and epiphyseal perforating arteries.

c) Periosteal plexus.

KINEMATICS

The global motion of the wrist is composed of flexion, extension and radio ulnar deviation at the radio carpal joint and axial rotation around the distal radio ulnar joint.

The radio carpal joint acts as a universal joint, allowing a small degree of intercarpal motion around the longitudinal axis related to rotation of the individual carpal bones.

The Forearm accounts for the most of the rotation (about 140 degree) and supplies the hand with the strength necessary to apply vigorous torque.

Radio carpal joint motion is primarily Flexion – Extension of nearly equal proportions [70 degrees each), radial and ulnar deviation of 15° and 45° respectively. Most adduction occurs at the radiocarpal joint; the lunate bone, articulating with both radius and articular disc when the hand is in mid-position, in adduction passes off the disc to articulate solely with the radius.

Abduction occurs almost entirely at the mid-carpal joint. Circumduction of the hand is not rotatory but successive flexion, adduction, extension and abduction or the reverse.

Abduction – adduction movements are of special functional value. The hand is commonly used with the carpus slightly extended and the forearm in mid-position. Skilled abduction, adduction movements manipulate a large variety of precision tools, from fine needles to hammer.

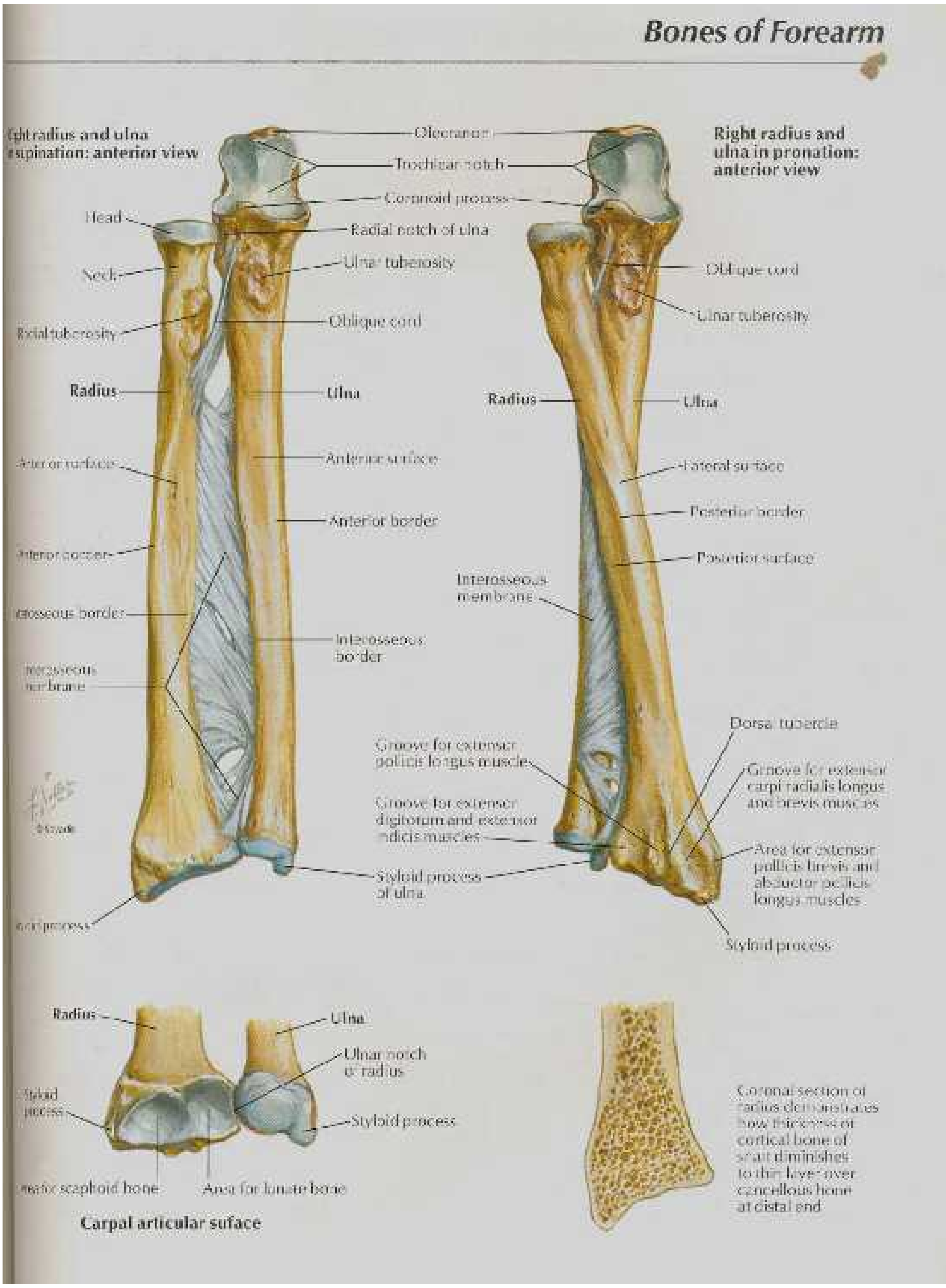


Fig:6 Anatomy of forearm

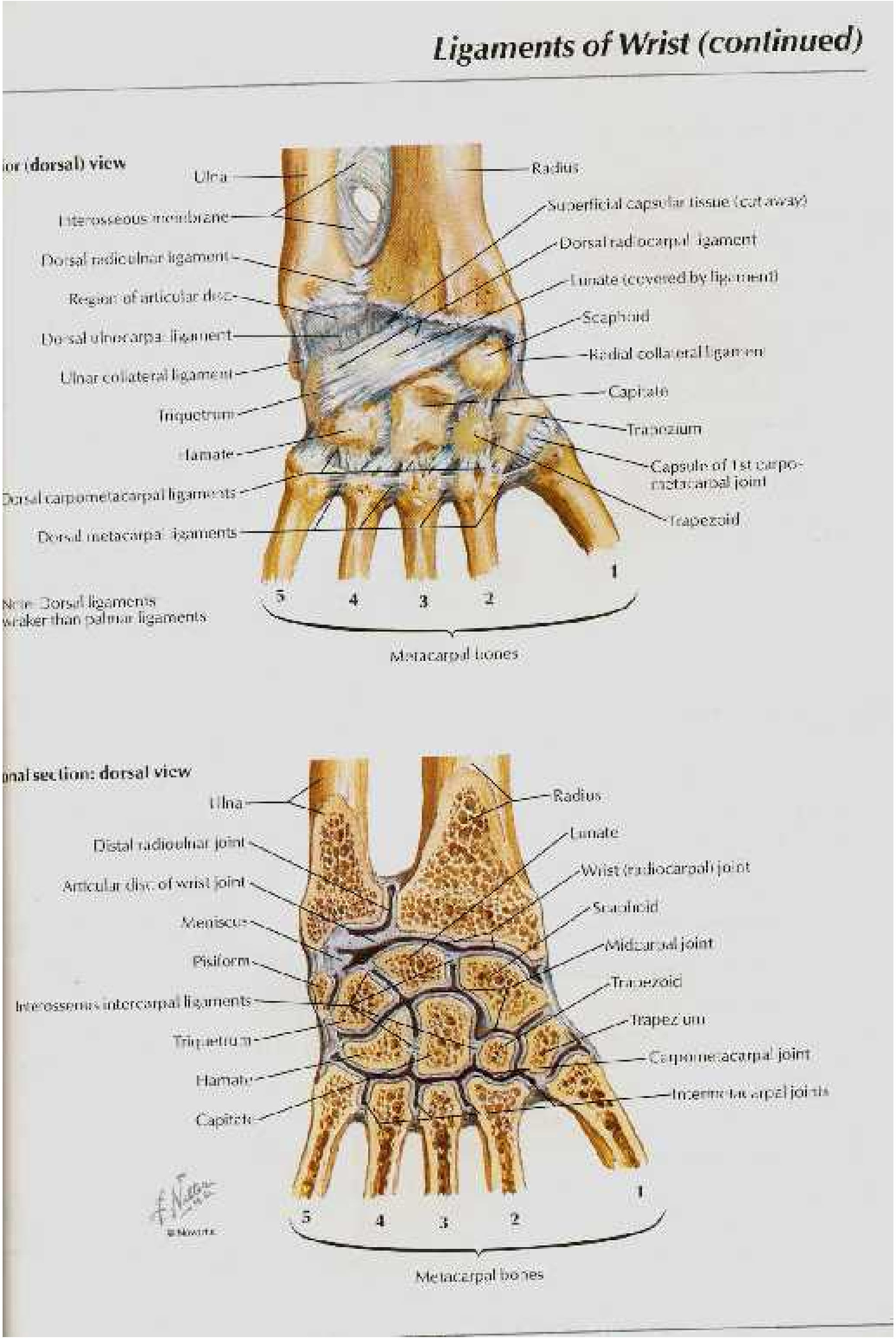


Fig:7 Distal radius and ligaments above and distal radioulnar joint with carpal bones

CLINICAL FEATURES

Patient comes with history of fall on outstretched hand or road traffic accident comes with pain, swelling and deformity of the wrist.

Clinical signs: Bony tenderness, Crepitus, range of movements painful and restricted.

IMAGING TECHNIQUES

Fractures of the distal radius are the most common fractures of the upper extremity and account for 17% of all fractures treated in the emergency room. Initially thought to be simple fractures, they are now recognized as complex injuries with a high percentage of long term complications.

The carpus and the distal radius and ulna are intimately connected by a complex array of palmar and dorsal ligaments such that distal radial and ulnar fractures may be associated with carpal fractures and dislocations.

In patients with uncomplicated and simple fractures, conventional roentgenograms in two planes are usually sufficient to make diagnoses. However, in patients with intra-articular and comminuted fractures, in patients with associated injuries of the wrist, as well as in post-operative follow-up, advanced imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI) and Scintigraphy may be necessary.

RADIOGRAPHY

A routine roentgen graphic examination should be performed first and is in many patients with distal radius fractures sufficient for correct diagnosis and adequate treatment. It is easy to perform, universally available and inexpensive.

The routine minimal evaluation for distal radius fractures must include two views,

a) Postero anterior. b) Lateral

A semi supinated oblique view can be obtained to help detect and depict various fracture lines.

The **PA view** should be obtained with the humerus abducted 90 degrees from the chest wall so that the elbow is at the same level as the shoulder and flexed 90 degrees. The palm of the hand maintained flat against the film cassette.

Fig8: (a) Lateral view (b) 10˚ Lateral view showing volar tilt (c)PA view (d) Positioning of the wrist for PA view and Lateral view

For **the lateral view**, the humerus is adducted against the chest wall and the elbow flexed 90 degrees. The wrist and hand are maintained flat against the film cassette.

Freiberg and lundstrom have found that lateral views taken with the central ray directed 15 degrees proximally provide significantly more exact measurement of the palmar tilt of the distal radial joint surface in comparison with a projection obtained with the central ray perpendicular to the forearm. The reason for this is that a perpendicular projection is not tangential to the plane of the distal radius slope and, therefore, will yield less easily defined measuring points than the other projection.

In a standard lateral projection, the radiograph beam is oriented perpendicular to the long axis of the radial shaft. Because the radial inclination of the ulnar two third of the articular surface is 10˚to the long axis of the shaft, this results in an oblique projection of the joint surface on the standard lateral view.

The 10˚lateral projection positions the articular surface in profile, allowing direct visualization of any offset in the sagittal plane and accurate identification of the apical ridges of the dorsal and volar rims. This projection is performed simply by elevating the distal forearm 10˚from horizontal or by aligning the beam 10˚ proximally.

The radial styloid is visualized on the lateral projection as a V-shaped outline superimposed over the lunate with a base extending from the dorsal and palmar margins of the distal radius.

Four measurements obtained from the PA and lateral views are important for accurate treatment and sufficient radiological follow up after distal radius fractures.

The four measurements are

i) The **radial angulation (or inclination**) describes the relative angle of the distal radial articular surface on the PA view to a line perpendicular to the long axis of the radius. This angle should be between 16 and 28 degrees, averaging around 20 degrees. Loss of this angle indicates a radial fracture, generally with impaction or overlap of fragments.

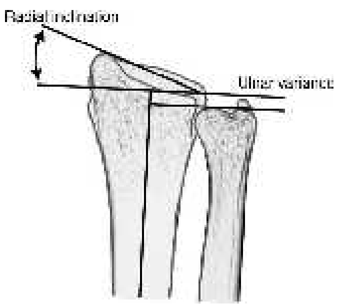


Fig:9(a) Radial inclination (b)PA view with X measuring the radial inclination

ii) A second measurement of distal articular surface of the radius is **Palmar tilt**

This is measured on the lateral radiograph, as the angle created between the articular surface of the distal radius and a line perpendicular to the long axis of the radius and is between 0 and 22 degrees (mean, 14.5 degrees and standard deviation, 4.3 degrees)

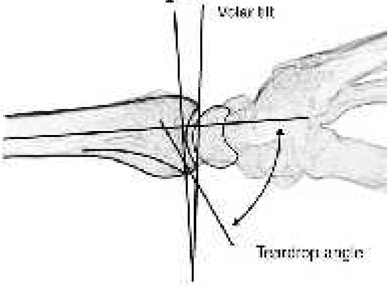


Fig:10(a) Volar tilt (b)lateral view with X measuring volar tilt /palmar tilt

iii) The **radial length**, also measured on the PA radiograph, relates the length of the radius to the ulna by the distance between two perpendicular lines to the long axes of the radius, one joining the tip of the radial styloid process and the other, the surface of the ulnar head. Normally the radial length averages **11 to 12 mm**.

Fig:11 PA view with X measuring the radial length

iv) Another measurement of the accuracy of reduction for articular fractures is the vertical distance between the distal ends of the medial corner of the radius and the ulnar head.

v) Another radiographic measurement on the PA view is the radial shift (or radial width).

Fig:12 X measuring the radial shift

This is the distance between the longitudinal axis through the center of the radius and the most lateral point of the radial styloid process. Both the injured and uninjured wrists are measured and compared. The measurements should be within 1 mm of each other in length.

Measure	Description	Normal Values	Acceptable Reduction
Radial Inclination (PA View)	Angle between a line drawn from the tip of the radial styloid to the most distal ulnar aspect of the lunate facet and a line perpendicular to the longitudinal axis of the radius.	13-30° Average=23°	>15°
Radial Length (PA View)	Longitudinal difference between a line perpendicular to the long axis of the radius drawn at the radial styloid and another line tangential to the distal articular surface of the ulna.	8-18mm Average=11mm	Loss of <5mm
Palmar Tilt (Lateral View)	The angle between a line joining the dorsal and volar margins of the articular surface and the long axis of the radius.	0-28° Average=11°	0-20° volarly
Radial Shift (PA View)	The distance between the long axis of the radius and the most radial point of the styloid	*Bilateral comparison*	
Intra-articular Step Off (PA View)	Incongruity in the articular surface (radio-carpal and DRUJ articular surface)		<2mm

Fig:13 table shows radiographic measurements normal values & acceptable values

Fernandez reports that a dorsal tilt of the distal radial surface of more than 25 degrees becomes symptomatic, whereas Pogue reports that 20 degrees of dorsal inclination causes problems.

Taleisnik and Watson report that even small changes in palmar tilt lead to radiocarpal dysfunction.

Similarly, there are different interpretations concerning radial shortening as the primary cause of poor end results ; some investigators suggest that 2 or 2.5 mm of radial shortening leads to changes in loads within the wrist.

Involvement of the distal radioulnar joint in fractures of the distal radius (Frykman fracture types V to VIII) can usually be recognized adequately on routine PA and lateral views. On the PA radiograph, the distal radioulnar joint should measure approximately 2 mm. Incongruity at this joint may cause diastasis or narrowing of this joint space, but if it does not, subluxation or dislocation of the distal radioulnar joint may be overlooked

Scintigraphy (Radionuclide Bone Imaging)

For radionuclide bone imaging, technetium 99 m coupled to phosphate compounds such as methylene diphosphonate is generally used.

Phase I : imaging (radionuclide angiography), obtained during the first 1 to 2 minutes after injection of the radionuclide, provides valuable blood flow information

Phase II : imaging (Blood pool images), obtained approximately 5 minutes after injection.

Phase III : imaging (Delayed bone images), obtained 2 to 3 hours later, are useful for detecting abnormalities of soft tissues or bones respectively.

Radionuclide bone imaging may be helpful for determining the age of a fracture as well as for documenting fracture healing when roentgenograms are inconclusive. In the acute phase (at 3 to 4 weeks), all 3 phases are positive.

In the sub acute phase (10 to 12 weeks), findings becomes normal, and the findings of blood pool imaging as well as that of delayed bone imaging remain positive but become more focal with respect to the fracture line.

In chronic phase, the findings of radionuclide angiography and blood pool imaging are normal, and the activity on delayed bone imaging slowly decreases over 3 to 8 months.

It is an important imaging technique for the diagnosis of reflex sympathetic dystrophy.

Computed Tomography

In selected difficult instances, such as complex or occult fractures, in evaluation of the distal radioulnar joint and distal radial articular surface, as well as in the assessment of fracture, healing and post surgical evaluation, CT may be useful and may add significant information in comparison with that obtained with conventional radiography.

CT may be indicated for the confirmation of occult fractures suspected on the basis of the findings of physical examination and focally hot to very hot bone scintigrams when plain films are normal, for the preoperative evaluation of complex distal radius fractures which are comminuted, and for the exact evaluation of the distal articular surface of the radius.

The axial plane is useful to show the configuration of the fracture patterns involving the distal radial articular surface.

The sagittal and coronal planes are useful for demonstration of the congruity and angulation of the radiocarpal joint surface, the degree of dorsal and ventral surface comminution, as well as elevation or depression of the distal radial articular surface.

CT is the modality of choice for corroborating distal radioulnar incongruency.

MAGNETIC RESONANCE IMAGING :

Although MRI cannot be used as the first choice modality for evaluating acute fractures, it is a powerful diagnostic tool to assess bony, ligamentous and soft tissue abnormalities that frequency are related to distal radius fractures.

MRI has proved to be a very important diagnostic tool for evaluating occult fractures and post traumatic or vascular necrosis of carpal bones.

BIOMECHANICS OF THE WRIST

The movements of radiocarpal and intercarpal joints are considered together as a common mechanism acted on by the same muscles. Active movements are flexion (85°), Extension (85°), adduction [ulnar deviation], abduction (radial deviation) and circumduction.

In carpal flexion, radiocarpal and mid-carpal joints are involved, the range being greater at the latter, in extension the reverse occurs, with more movement at the radiocarpal. Hence the proximal surfaces extended further posteriorly on the lunate and scaphoid bones. These movements are limited chiefly by antagonistic muscles, therefore the range of flexion is perceptibly diminished when the fingers are flexed, due to increased tension in the extensors. Only when the joints are forced to the limits of flexion or extension are dorsal or palmar ligaments fully stretched.

Adduction of the hand [45°] is considerably greater than abduction [15°], perhaps due to the more proximal site of the ulnar styloid process. Most adduction occurs at the radiocarpal joint, the lunate bone, articulating with both radius and articular disc when the hand is in mid-position, in adduction passes off the disc to articulate solely with the radius. Much of the proximal articular surface of the scaphoid becomes sub-capsular beneath the radial collateral ligaments and forms a smooth, convex, palpable prominence in the floor of the anatomical "Snuff" box.

Abduction occurs almost entirely at the mid-carpal joint, radiographs of abducted hands show that the capitate rotates round on AP axis so that its head passes medially and the hamate conforms to this, the distance between lunate and the apex of hamate is increased. The scaphoid rotates around a transverse axis ; its proximal articular surface has retreated from the capsule and is now in sole articulation with the radius. Movements are limited by antagonistic muscles and at extremes by the collateral carpal ligaments.

Circumduction of the hand is not rotatory but successive flexion, adduction, extension and abduction or the reverse.

Abduction – adduction movements are of special functional valve. The hand is commonly used with the carpus slightly extended and the forearm in mid-position. Skilled abduction – adduction movements manipulate a large variety of precision tools.

MECHANISM OF INJURY

Fall on an outstretched hand with wrist in hyperextension is usual mode of injury either involving vehicular accident (notably motor cycle accidents), blow on a closed fist or fall from height on level ground.

With the wrist in 40˚ to 90˚ of dorsiflexion, a fall on the outstretched hand will produce a distal radius fracture with dorsal displacement. The injury pattern will depend on the magnitude and direction of force and the physical properties of the bone.

The wrist usually lands in extension and the forearm in pronation. The lunate acts as a wedge to shear the radius off in a dorsal direction. The dorsal surface undergoes compression while the volar surface undergoes tension. The momentum from the fall often caused sprain of the ulnar collateral ligament and an avulsion fracture on the ulnar styloid process.

CLASSIFICATION OF DISTAL RADIUS FRACTURES

Eponyms such as Colle's, Smith & Barton fracture have been used to describe fractures of the distal end of the radius and continue to be used in the current literature. Unfortunately, the confusion resulting from this inaccurate method of classification has resulted, at times, in the publication of conflicting recommendations with regard to treatment and expected outcomes.

Gartland and Werley in 1951 and Lidstrom in 1959, developed systems of classification that were based on the presence, but not the extent of displacement of the site of the fracture and of the involvement of the radiocarpal joint.

In 1965, Older et al, published an extremely useful system of classification of metaphyseal colle's – type fractures that was based on extent of displacement, dorsal angulation, shortening of the distal fragment of the radius, and presence and extent of comminution of the dorsal metaphyseal cortex. They divided fractures into four groups, ranging from relatively non – displaced fractures (Type I) to considerably displaced fractures with extensive comminution, extension into the radiocarpal joint, and shortening of the distal fragment of two to eight millimeters proximal to the distal radio-ulnar joint (Type IV).

In 1967, Frykman established a system of classification that identified involvement of the radiocarpal and the radioulnar joint, as well as the presence or absence of a fracture of the ulnar styloid process. Although this has been accepted by many authors, the system does not include the extent or direction of the initial displacement, dorsal comminution, or shortening of the distal fragment. As such, it has less prognostic valve in evaluating the outcome of treatment.

FRYKMANN'S CLASSIFICATION

Type I	Extraarticular radial fracture
Type II	Extraarticular radial fracture + Ulnar styloid fracture
Type III	Intra articular fracture of the radio carpal joint.
Type IV	Intra articular fracture of the radiocarpal joint + Ulnar styloid fracture.
Type V	Fracture of the radioulnar joint
Type VI	Fracture of the radioulnar joint + Ulnar styloid fracture.
Type VII	Intra articular fracture involving both radiocarpal and radioulnar joints.
Type VIII	Intra articular fracture involving both radiocarpal and radioulnar joints with an ulnar styloid fracture.

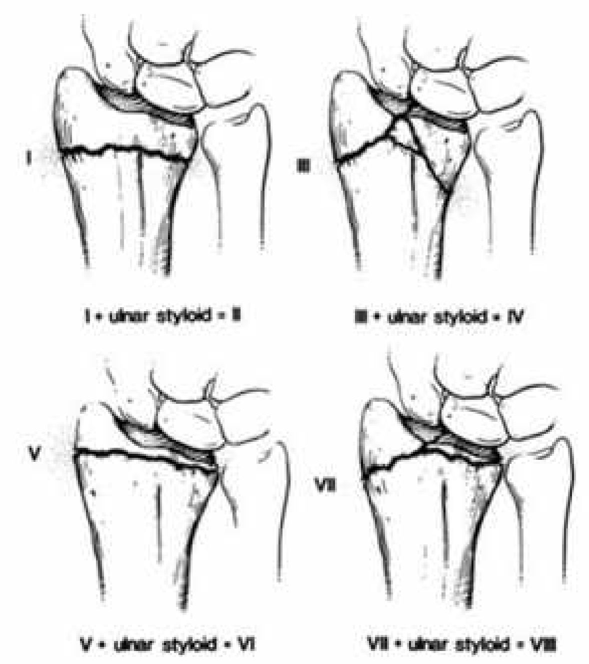


Fig:14 Frykmann's classification

Fernandez: Subdivided fractures of the distal end of the radius according to the mechanism of injury.

1) Bending	Metaphysis fails due to tensile stress (Colle's and Smith fractures).
2) Compression	Fracture of the surface of the joint with impaction of subchondral and metaphyseal bone (So-called die-punch fracture)
3) Shearing	Fracture of the surface of the joint (Barton & Chauffeur's fracture)
4) Avulsion	Fracture of ligamentous attachments (Fracture of the ulnar and radial styloid processes).

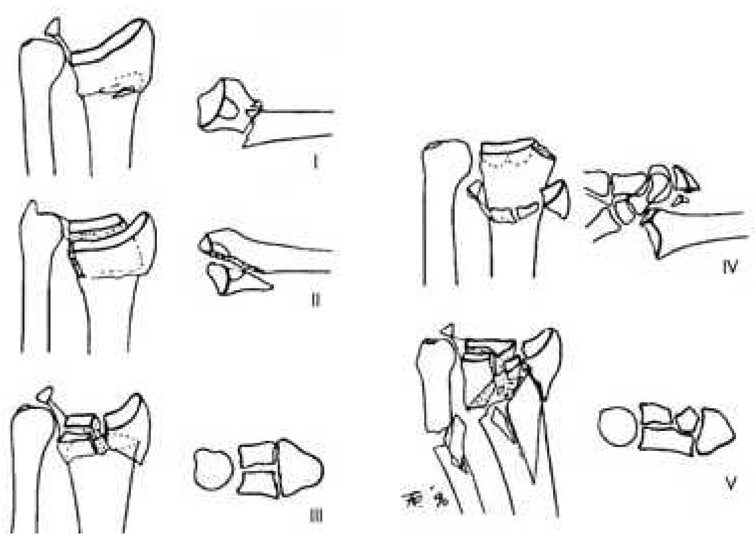


Fig:15 Fernandez classification

Mc Murtry and Jupiter defined intra-articular fractures on the basis of the number of their parts.

1) Two parts	The opposite portion of the radiocarpal joint remains intact (dorsal / palmar, Barton, Chauffeur and die-punch fracture)
2) Three parts	The lunate and scaphoid facets separate from each other and the proximal portion of the radius
3) Four parts	The same as the three parts, except the lunate facet is further fractured into dorsal and volar fragments.
4) Five parts or more	Including a wide variety of comminuted fragments.

MELONES CLASSIFICATION

1. Minimal comminution – stable
2. Comminuted – Stable displacement of medial complex posterior: die punch, Barton anterior, Smith.
3. Displacement of medial complex as a unit + anterior spike.
4. Wide separation or rotation of the dorsal fragment & palmar fragment rotation.

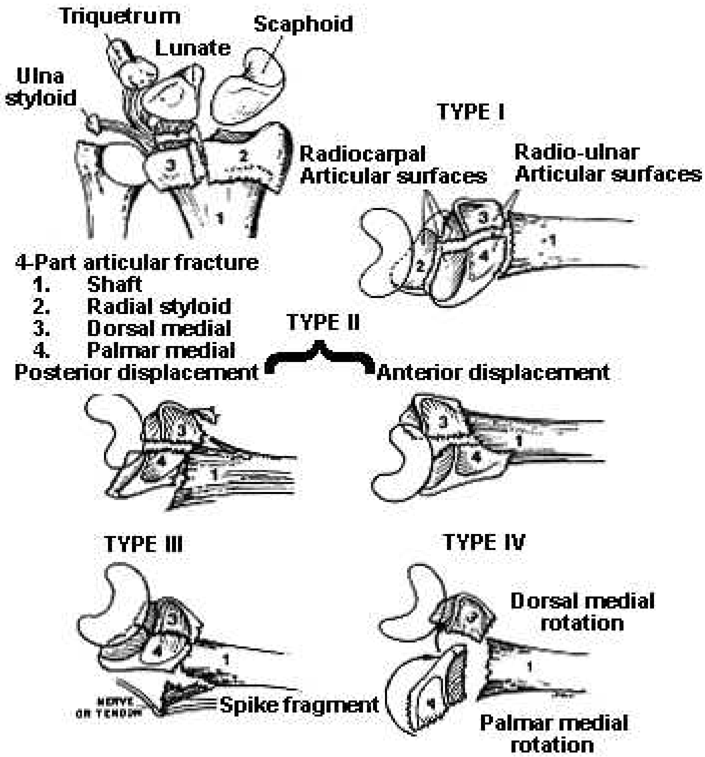


Fig:16 Melone's classification

Classification of Mayo, Intraarticular Fractures

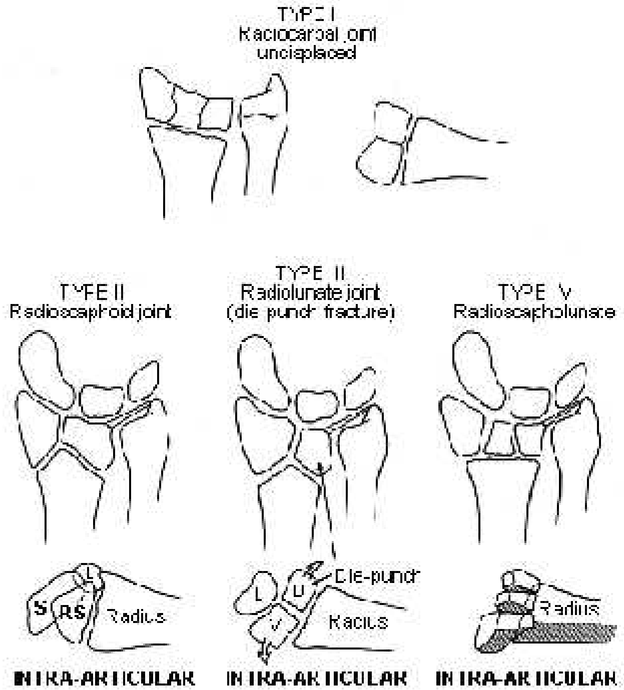


Fig:17 Mayo classification

AO CLASSIFICATION

The most detailed classification, to date, is the AO classification, which is organized in order of increasing severity of the osseous and articular lesions.

Type A Extra articular

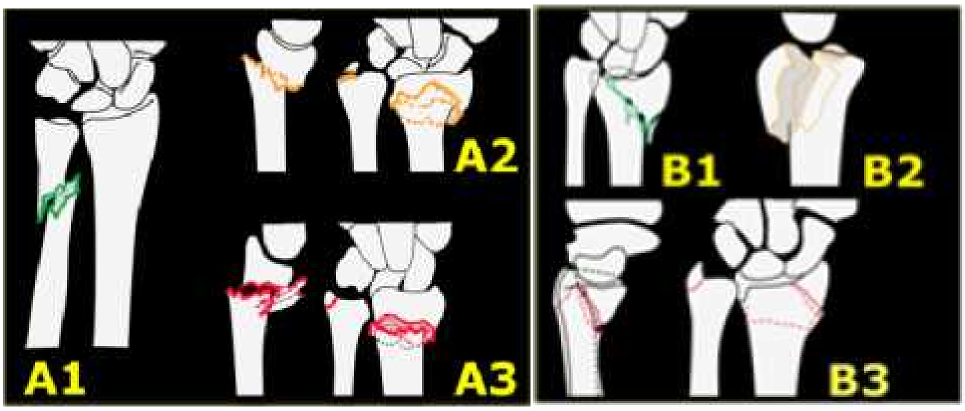
Type B Partial articular

Type C Complete articular

C1 Simple articular and metaphyseal

C2 Simple articular with complex metaphyseal

C3 Complex articular and metaphyseal fractures .



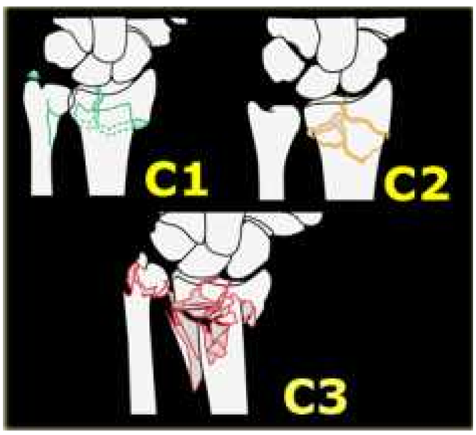


Fig:18 AO classification

A = extra-articular fracture A1 = ulna, radius intact A2 = radius, simple and impacted ,A3 = radius, multifragmentary

B = partial articular fracture B1 = radius, sagittal ,B2 = radius, frontal, dorsal rim

B3 = radius, frontal, volar rim

C = complete articular fracture of radius

C1 = articular simple, metaphyseal simple,C2 = articular simple, metaphyseal multifragmentary,C3=articular,multifragmentary

SURGICAL ANATOMY AND BIOMECHANICS:

The lower end of radius is expanded and rectangular in transverse section. Ulnar surface shows a notch for articulation with the head of ulna. Above this is a triangular area that receives pronator quadratus and has the interosseous membrane attached to its posterior edge. Laterally the lower end is projected into styloid process. The extensor retinaculum is attached to antero-lateral border above the styloid process. Septa passes from its deep surface to the radius making compartments. Four compartments lie on the radius. Inferiorly the articular surface forms the wrist joint has two concave areas covered with hyaline cartilage. The ulnar surface is square and articulates with Lunate, lateral concave area is triangular with its apex on styloid process and articulates with Scaphoid.[42]

The distal radial articular surface has a normal palmar inclination with average between 10 degree to 12 degree.[43-45]

It has an ulnar inclination or radial angle averaging 22 degrees to 23 degrees.[46-47]

Ulnar portion of Lunate facet is normally at the same level or within 2 mm of the radial portion of ulnar head. Their relative position is referred as ulnar variance.

Positive ulnar variance reflects a long ulna and can be associated with ulno-lunate impingement and degenerative tears of the triangular fibrocartilage.[48-50]

Negative ulnar variance can result in a increase in the proportion of carpal load born by Lunate facet of the distal radius, which may be related to avascular necrosis of Lunate.[51]

The traditional method of assessing relative shortening so called " radial length" involves calculation of the distance between perpendicular to the radial shaft drawn at the tip of radial styloid and at the ulnar aspect of distal articular surface. The average length is 11 mm to 12 mm. This distance is less useful, however, since it reflects loss of ulnar inclination of the distal articular surface in addition to relative radial shortening.[46]

The sigmoid notch, at the distal most aspect of the medial surface of the distal radius is covered with hyaline cartilage and forms 60 to 70 degree of arc via a radius of curvature of approximately 15 mm which articulates with ulnar head at the distal radio-ulnar joint.[52-53]

The surface of notch is slightly conical, with a smaller radius of curvature distally. Furthermore the articular surface has been described of having the normal radial tilt of about 20 degrees.[54]

Biomechanics:

Frykman was among the first to examine the pattern of fracture after specific loading of the distal radius but also observed different pattern of fracture depending on position of wrist and force applied on it. In his experiment he used cadaver wrist and simulated loading to produce fractures. He subsequently gave his fracture classification based on his observation.[55]

Subsequently Fernandez studied mechanism of injury and gave his classification. Walter H. Short done study of biomechanics, they simulated extra-articular fracture distal radius by doing osteotomy and studied weight transmission across the radiocarpal joint. They further modified dorsal angle and shortening of radius, and observed weight transmission pattern. They concluded that changing the angulation of distal radius significantly increases the percentage of force carried by ulna. At the normal position 21% of the force borne by ulna. At 30% change in the dorsal angle articular surface of ulna bears 50% of load. At 50% of change in dorsal angle increases force up to 65%. They further found as dorsal angle increases load is concentrated on dorsal and radial aspect of distal radius.[56-57]

After fracture radial shortening produces positive ulnar variance which is associated with ulno- lunate impingement and degeneration of triangular fibrocartilage complex and produces its dysfunction.[50,58] Radial shortenings in this setting can also cause in congruency of distal radioulnar joint.[50] Taleisnik described midcarpal instability of wrist following malunion of distal radius fracture.[59]

Radiology and measurements:

To evaluate distal radius fracture x-rays are taken in antero-posterior and lateral views. Most of the time normal side x-rays are also taken for comparison. There are many authors described how to measure the deformity and displacement.

The method described by Van Der Linden is more widely accepted. He measured radial angle also known as ulnar tilt in antero-posterior view. Radial displacement and radial length are also measured in antero-posterior view. In lateral view dorsal angle and dorsal displacement is measured. Dorsal angle is also known as volar tilt.[60]

The dorsal angle is measured from lateral view as the angle between a line connecting the distal most point of the dorsal and palmer rims of the articular surface and a line drawn perpendicular to the longitudinal axis of radius.

The radial angle is measured from a anteroposterior view as the angle between a line connecting the distal most points of the radial and ulnar rims of the articular surface and a perpendicular to the longitudinal axis of radius.

The radial length is measured from a anteroposterior view as the distance in millimeters between a line drawn at the tip of the radial styloid process, perpendicular to the longitudinal axis of the radius and a second perpendicular at the level of the distal articular surface of the ulnar head.

The radial and dorsal displacement is measured by distance of radial and dorsal most cortex from mid axis line of distal radius. It is the difference between injured and normal side.

The ulnar variance represents the vertical distance between the distal ends of the ulnar head and ulnar most aspect of the distal radial articular surface.[60]

CURRENT TRENDS IN TREATMENT

Distal radius fractures can be treated with a wide variety of treatment options available.

Conservative:

This involves immobilization of the wrist and hand in different positions by the means of cast application i.e. forearm pronated or supinated, in flexion ulnar deviation, in extension. The cast applied can be above elbow or below elbow.

Percutaneous direct pinning

The aim is to fix the mobile fragment to the opposite cortex proximal to the fracture. This type of pinning cannot prevent redisplacement of certain fragments.

Elastic intra / Extrafocal pinning :

This method is popular for extra-articular Fractures. The fracture is first reduced by external manoeuvres. The K-wire is then moved dorsally through the fracture site to penetrate the opposite cortex in a 45 degree proximal direction. The elastic force of the K-wire gives a persistent reduction and prevents redisplacement.

External Fixators :

These are based on the principle of ligamentotaxis. The traction is exerted mainly by the strong volar ligaments on the anterior rim of the distal radius. Central articular fragments are not reduced.

External Fixation with Pinning

In this external fixators are combined with direct pinning of the unreduced fragments. It is usually reserved for comminuted intra-articular fractures in young people.

Plate Fixation

In this there is open reduction with plate fixation which acts as a buttress and provides rigid fixation.

Locking compression plate

Locking compression plate shows significantly high load at failure compared to standard plating technique for lower bone mineral densities, hence it is advantageous to use in osteoporotic fractures.

COMPLICATIONS OF DISTAL RADIUS FRACTURES

1) Compressive Neuropathy

Median nerve involvement (carpal tunnel syndrome) the most common, usually associated with reduction of the fracture in the emergency room under local anaesthesia. Radial neuropathy can arise as a result of improper immobilization and from external pin fixation.

2) Arthrosis after Fracture

This is associated with painful motion of the wrist or forearm. Radio-ulnar arthrosis was more common than radiocarpal arthrosis. Frykman Type VI, VII and VIII fractures most often elicit this complication.

3) Malunion

Malunion commonly results when the fracture is unstable and comminuted.

4) Tendon injuries

Rupture of the extensor pollicis longus and rupture of the index flexor digitorum profundus or flexor pollicis longus. The rupture is related to bone fragments from displaced fractures that abrade the tendon during the weeks after healing of the fracture.

5) Volkman's Ischemic Contracture

This can arise as a result of application of a constricting cast.

6) Shoulder – Hand Syndrome

This is more appropriately called upper-limb dystrophy or pain-dysfunction. It includes predominant sympathetic components of change in skin temperature, colour and texture, pain and loss of motion in the shoulder and stiffness of the hand or special local trigger areas of exquisite pain and tenderness (or both).

7) Stiff hands

It is manifested by pain and swelling limited to the hand, with loss of finger motion and occasionally loss of motion of the wrist.

8) Unrecognized Associated injuries

These include scaphoid fractures, radial head fractures, Bennett's fracture and intercarpal ligament injuries.

9) Complications associated with external fixators

a) Loss of radial length :

This is attributable to the failure of the device to maintain sufficient distraction or can result because of early removal of fixator.

b) Loosening of pins :

Loosening of pins can result as a result of infection or osteporosis. To diminish this complication, some authors have recommended use of large diameter pins, placement of pins in the index and middle metacarpals., avoidance of external fixators in elderly patients.

c) Stiffness of wrist, osteoporosis

This arises as a result of rigid immobilization over a long period of time with reduced blood supply to the bone and soft tissue.

d) Reflex sympathetic dystrophy

Cooney reported an incidence of 5% in 100 patients treated with a variety of external fixators.

METHODOLOGY

Fifteen patients with intra-articular fractures of the distal end of radius were treated with external fixator and fifteen patients were treated with locking compression plate under Department of Orthopaedics.

Study design: A randomised controlled trial

Study period: The study is being conducted from December 2008 to July 2010

Sample size: The 15 cases in each group in a period of 1 & 1/2 year.

Total number=30 Randomisation is done by sealed envelope method.

There were 21 males and 9 females between the age group of 20 – 65 years. Injury occurred due to road traffic accident in 21 cases, fall on outstretched hand in 8 cases and fall from height one case.

The dominant wrist (Right) was affected in 16 cases and 14 patients had injury to left wrist. One patient had ipsilateral supracondylar Femur shaft fracture 1 with Lefort's fracture and 1 bimalleolar fracture.

SELECTION CRITERIA

Inclusion criteria

1. Frykmann's type VII & VIII.
2. Irrespective of age

Exclusion criteria

1. Frykmann's type I to VI .
2. Pathological fractures

The patients came with complaints of deformity, pain and swelling of the wrist associated with restricted and painful movements, of the wrist. Tenderness could be elicited over the lower end of radius and the relative position of radial styloid and ulnar styloid process were altered.

None of the cases of present study had any median nerve involvement or any tendon injury.

All the patients were evaluated with x-rays in two views.

1) Anteroposterior [A.P]
2) Lateral views.

The fractures were classified according to Frykman's classification in our series.

In the elderly patients diabetes was ruled out and so was hypertension. Random Blood sugar estimation, E.C.G and blood pressure recording were made. None of the elderly patients in our series had diabetes or hypertension or any other major illness

Routine blood investigation [Haemoglobin, Bleeding Time, Clotting time, urine – Routine & Microscopy] were done. Consent for surgery was taken.

ANAESTHESIA

Brachial Block was given in all of the 20 cases. The static External Fixator [UMEX] used in this series consisted of

1) 2.5 mm K wires - 4 in number
2) Clamp - 4 in number
3) Distraction Rod.

OPERATIVE TECHNIQUE – External fixator

The patient was placed supine on the operation table. No tourniquet was used. Intravenous antibiotics in the form of 1 gm of ceftriaxone was administered before the start of the procedure. The arm, Forearm, hand was scrubbed with betadine scrub and was painted with betadine and spirit and then draped. The limb was placed on side board [Hard].

Under C-arm control closed reduction of the fracture was carried out, two stab incisions, one at the lateral aspect of the shaft of the 2^{nd} metacarpal and another, one inch distal to the former. Through each incision, one K-wire was drilled passing through 4 cortices [i.e. 2^{nd} & 3^{rd} Metacarpal]. Another two stab incisions were made, the first approximately 8 cms proximal to fracture site and another one inch proximal to the first incision. Taking care not to injure the tendons, nerves and vessels (bare area), one 'K' wire was passed through each incision and penetrating both cortex of the radius. The distraction rod was then connected to all the 4 K-wires by means of clamps. Under image intensifier guidance, further distraction if necessary was carried out by the fixator. At the end of the procedure sterile dressing was applied over the pins. No cast or splint was given.

Antibiotics [Intravenous] was continued over the next post-operative day and was then switched over to oral antibiotics (cefuroxime 500 mg tid) for the next 5 days. All the cases were operated within 1 to 3 days of injury.

Post-Operative care and Rehabilitation:

Immediate post-operative check x-rays were taken in both AP and lateral views. Active exercises of all the fingers, elbow and shoulder were carried out.

The patient was discharged on the 3rd post-operative day after the first dressing change the patient was called for inspection and dressing change at the interval of one week for the next 6 weeks. The patient was assessed subjectively for pain at the fracture site, clinically for tenderness and loosening of the pins.

The external fixator was removed on the 6th week without any anaesthesia. Check X-ray was taken in both AP and lateral view. The range of motion at the wrist was recorded and any deformity was assessed. Physiotherapy was carried out regularly for 2 weeks.

All the cases were followed at an interval of 6 weeks, 3 months & 6 months. The follow up ranged from 1 month to 6 month with an average of 3 months.

There was loosening of pins in only one case during the 4th week for which the fixator was removed on the 5th week. Following removal no displacement was noted.

Instruments used for External fixator and k-wire fixation:

Fig:19 Instruments used for external fixation and k-wire fixation

Instruments used for LCP

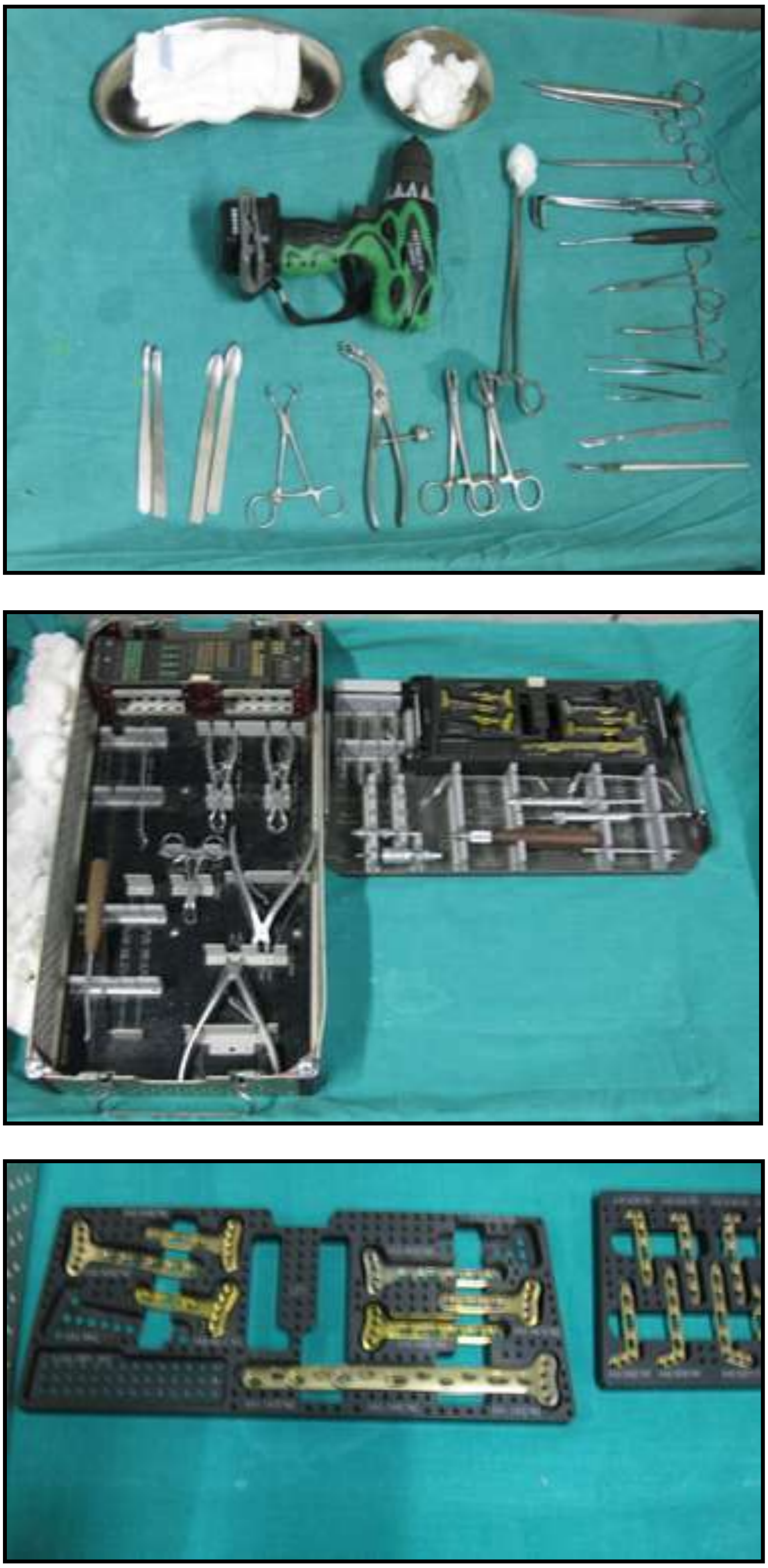


Fig: 20 Instruments used for locking compression plate

OPERATIVE TECHNIQUE – Locking compression plate

The patient was placed supine on the operation table. No tourniquet was used. Intravenous antibiotics in the form of 1 gm of ceftriaxone was administered before the start of the procedure. The arm, Forearm, hand was scrubbed with betadine scrub and was painted with betadine and spirit and then draped. The limb was placed on side board [Hard].

Fig: 21 Positioning of the arm

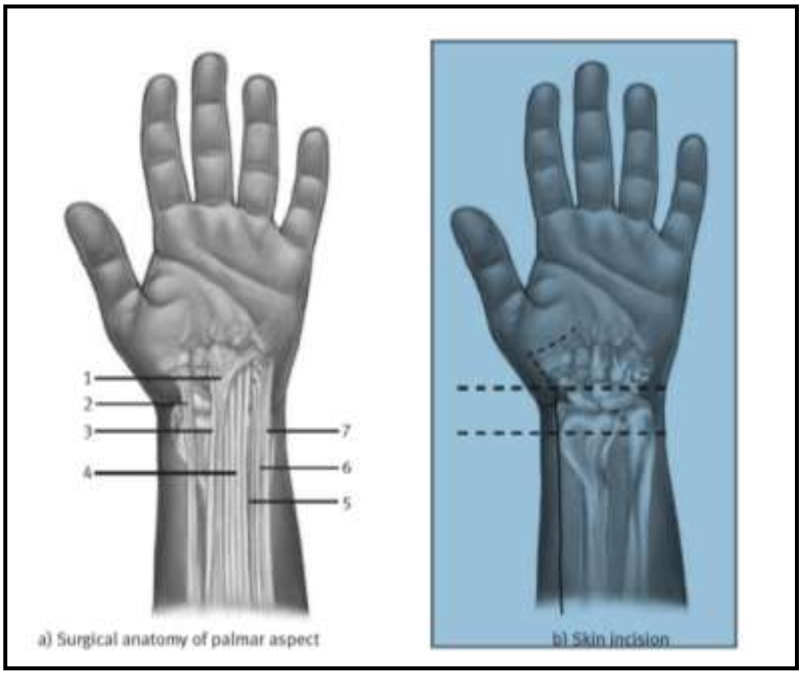


Fig :22 Surgical anatomy and skin incision

A Henry incision in the distal forearm was selected, and then the skin was incised along the flexor carpi radialis muscle tendon and radial artery. The radial artery was protected and retracted to the radial side and the flexor carpi radialis muscle tendon and median nerve was retracted to the ulnar side. The quadrate pronator muscle was exposed.

Fig :23 Distal radius after detachment of pronator quadratus

The pronator quadratus was detached from the radial side, to provide good exposure for anatomic reduction of the palmar cortex of the distal radius and for placement of the plate.

Fig: 24 Locking compression plate

After radial height, volar tilt angle and articular surface were corrected, the fracture reduction should be maintained by temporary Kirschner wire fixation.

The LCP placed in position, locking sleeve is used to drill both the cortices. Locking screws are placed and the correct reduction is confirmed with C-arm.

A thorough wash .underlying structures sutured in layers followed by skin closure and betadine dressing done. The forearm is immobilised in a below elbow slab.

Post-Operative care and Rehabilitation.

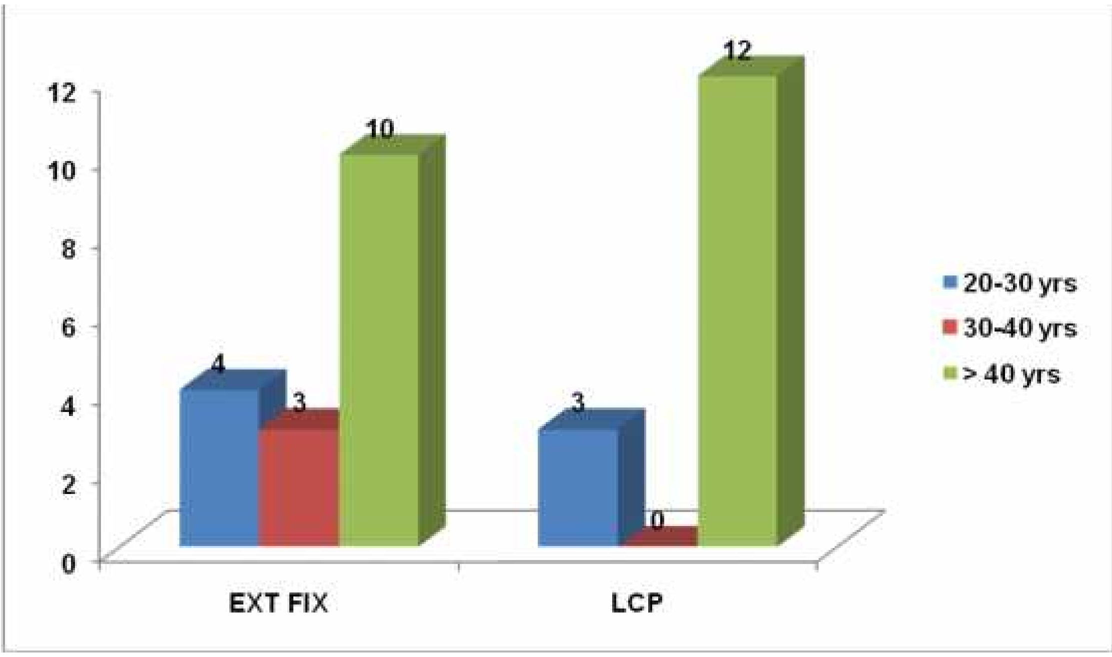
Immediate post-operative check x-rays were taken in both AP and lateral views. Active exercises of all the fingers, Elbow and shoulder were carried out. Regular dressings were carried out every alternate day. Sutures were removed at 10 post-operative day.

RESULTS

Table No. 1: Age Distribution

Group	20-30 yrs	30-40 yrs	> 40 yrs
EXT FIX	4	3	10
LCP	3	0	12

There were four in second three in third and ten in above fourth decade in external fixator group , three in second, twelve in above fourth decade in LCP group.

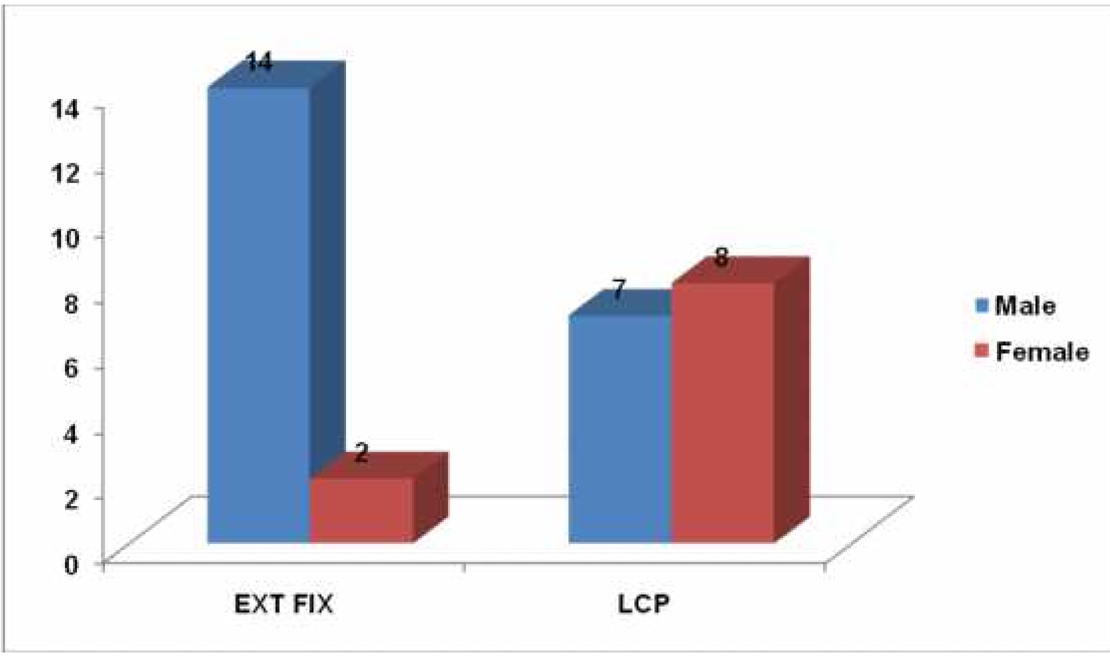


Graph No. 1: Age Distribution

Table No. 2: Sex Distribution

Group	Male	Female
EXT FIX	13	2
LCP	7	8

There are thirteen male and two female in external fixator group , seven male and eight female in LCP group.

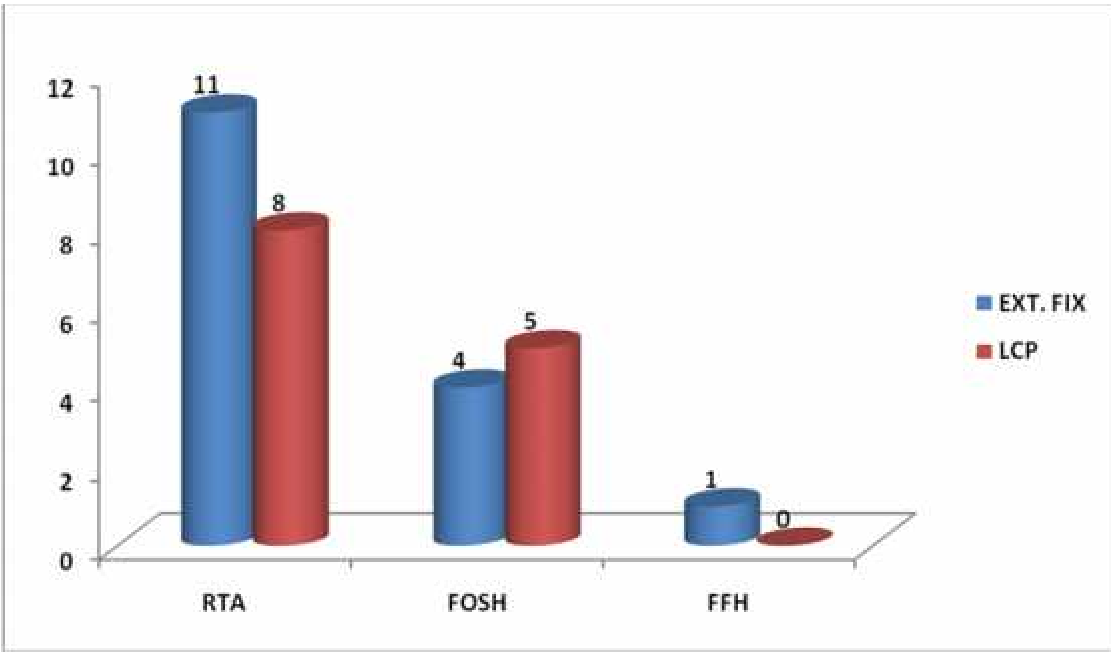


Graph No. 2 : Sex Distribution

Table No. 3: Mechanism of Injury

Group	RTA	FOSH	FFH
EXT. FIX	11	4	1
LCP	8	5	0

There are eleven road traffic accident, six fall on outstretched hand and one fall from height in external fixator group ,eight road traffic accident, five fall on outstretched hand in LCP group.

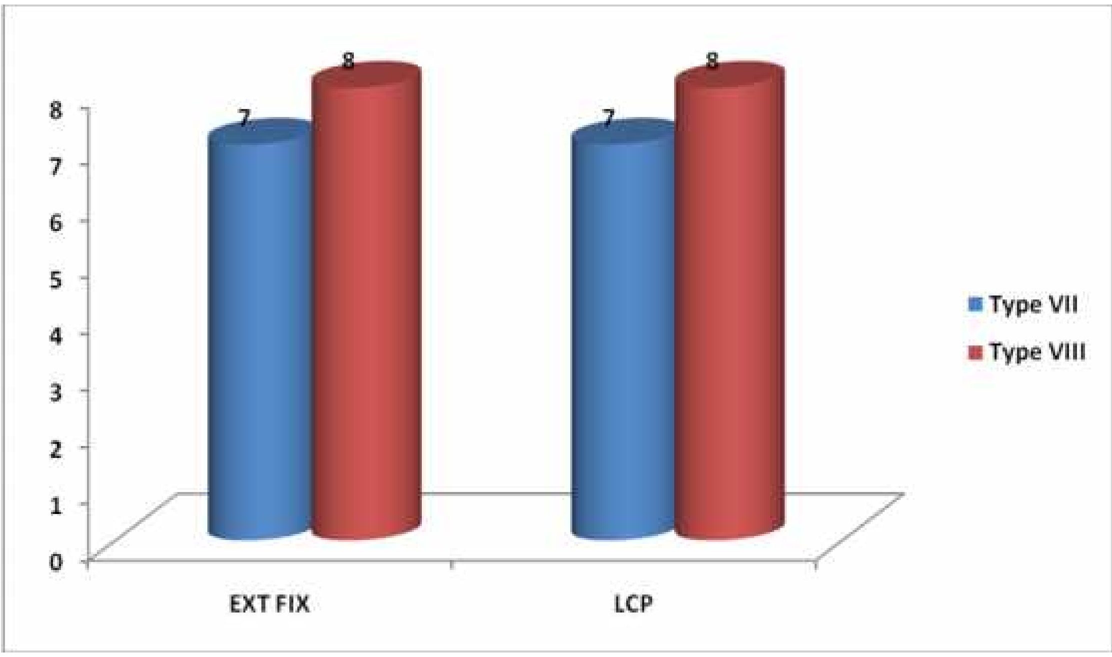


Graph No. 3: Mechanism of Injury

Table No. 4: Frykmann Type

Group	Frykmann	
	Type VII	Type VIII
EXT FIX	7	8
LCP	7	8

There were seven Frykmann type VII and eight Frykmann type VIII in both external fixator and LCP group.

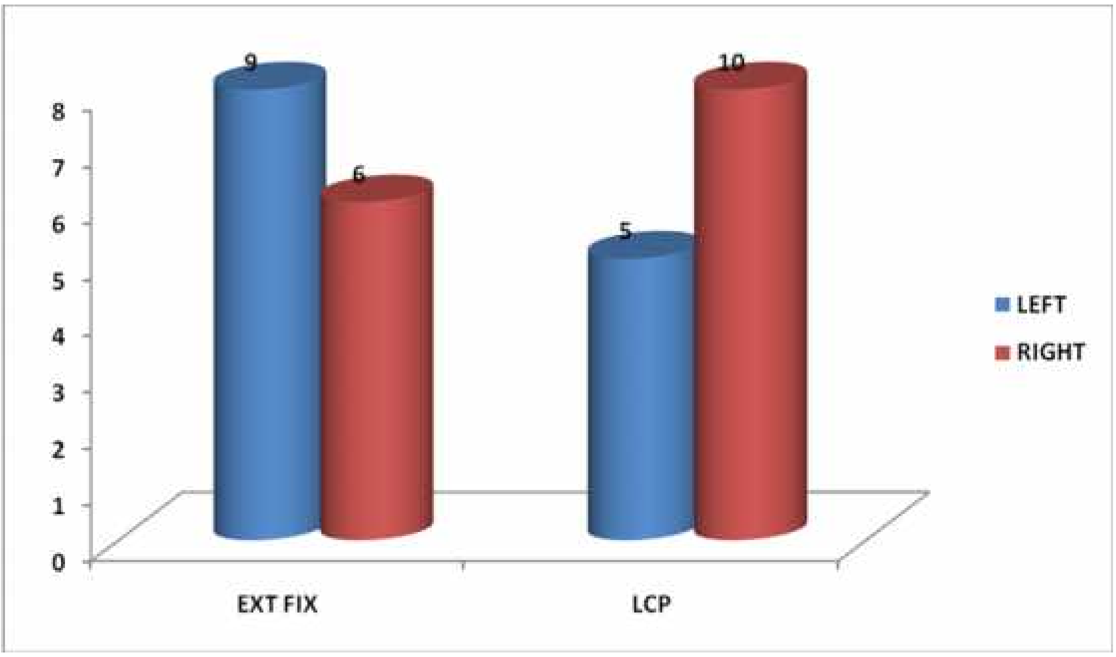


Graph No. 4: Frykmann Type

Table No. 5 : Laterality

Group	LEFT	RIGHT
EXT FIX	9	6
LCP	5	10

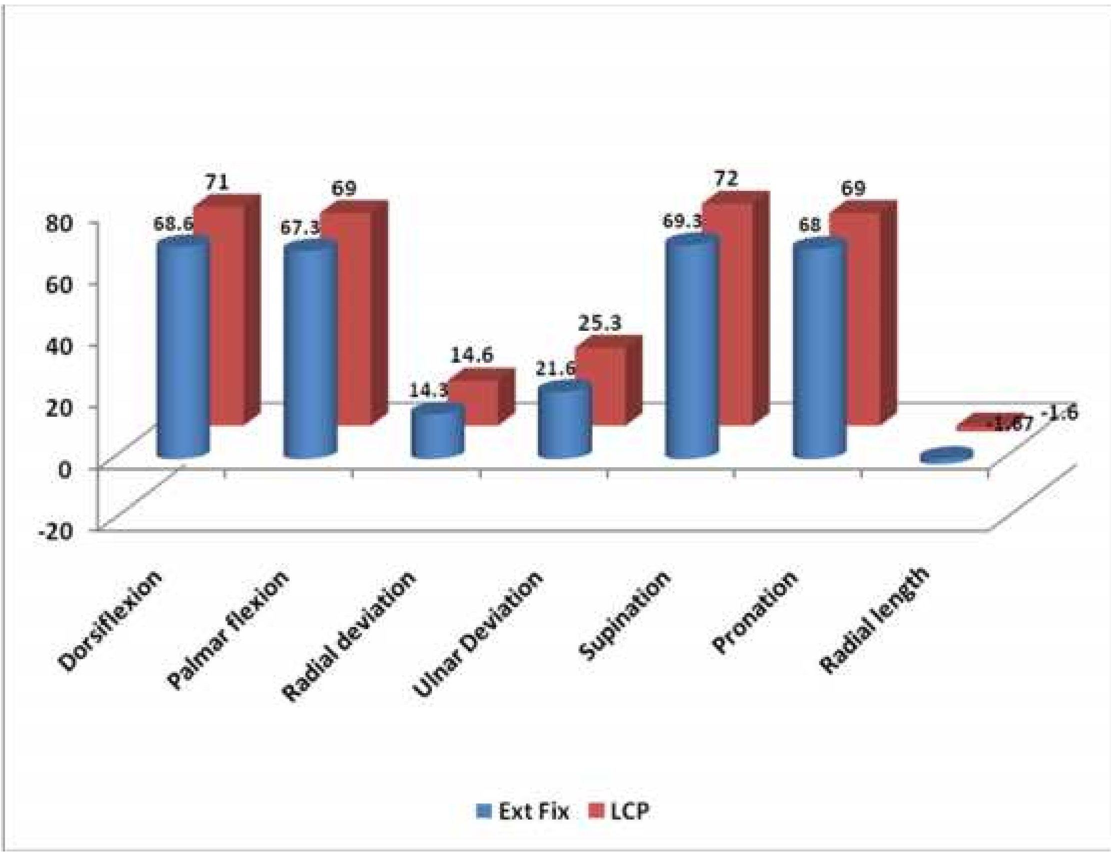
There were nine left and six right wrist affected in external fixator group, five left and ten right wrist affected in LCP group.



Graph No. 5: Laterality

Table No. 6: Range of movements and radial length

	Ext Fix	LCP
DF	68.6±11.09	71 ± 8.90
PF	67.3 ± 10.99	69 ± 10.55
RD	14.3 ± 1.76	14.6 ±1.29
UD	21.6 ± 7.71	25.3 ±6.39
SUP	69.3 ± 7.53	72± 8.41
PRON	68± 8.41	69 ± 9.48
RAD LENGTH	-1.67 ± 0.89	-1.6 ± 8.2

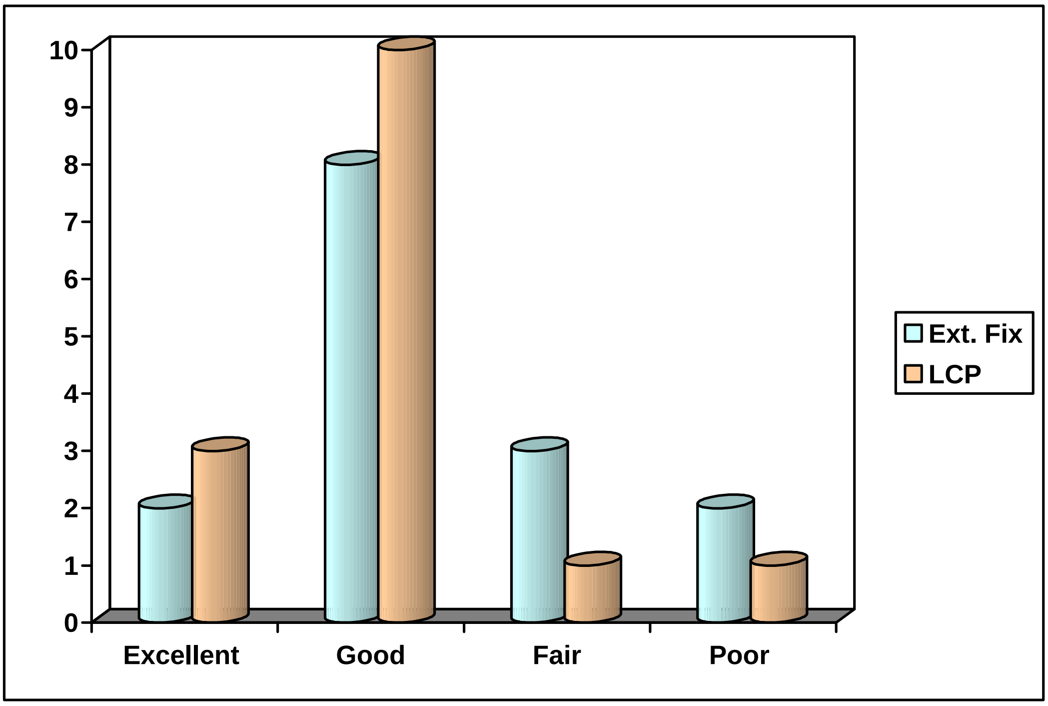


Graph No. 6: Range of movements and radial length

Table No. 7: Outcome

	Ext Fix	LCP
Excellent	2	3
Good	8	10
Fair	3	1
Poor	2	1

2 patients achieved excellent , 8 patients had good, 3 fair results and 2 patients had poor results.LCP results: 3patients achieved excellent10 had good and 1achieved fair and 1 poor outcomes.



Graph No. 7: Outcome

DISCUSSION

Distal radius fractures are extremely common injuries and tend to occur in a bimodal age distribution. They are seen most frequently in young adults and again later in life in elderly, osteopenic women.

These fractures are frequently articular injuries resulting in disruption of both the radiocarpal and distal radio ulnar joints.

Most distal radius fractures are low-energy fractures, the result of a fall, and may be treated nonoperatively with some form of closed immobilization. High-energy distal radius fractures are more common in younger adults.

In each of these subsets of patients the need for operative stabilization may arise. The high-energy fractures frequently have articular comminution and displacement that require open means to reduce. A percentage of some of the comminuted, osteoporotic low-energy fractures may be unstable injuries that require operative stabilization. The need for operative fixation of distal radius fractures in the elderly is becoming more common as the life expectancy in society increases and the elderly population stays more active and physiologically healthier.

EXTERNAL FIXATION

The use of external fixators in the treatment of distal radius fractures is common. External fixation can be used for various injuries about the wrist and in combination with other fixation methods.

Currently the trend is toward open reduction and internal fixation (ORIF) and away from external fixation. However, we believe the external fixator is still a valuable tool for fracture treatment and through this review we will show its effectiveness.

Fractures of the distal end of radius continues to be one of the most common skeletal injuries of the upper limb.

In our series the majority of the cases of intra – articular fractures of distal end of radius were seen in the younger age group of patients with road traffic accidents [Fall from Motor bike] being the most common.

Several authors[61,62] have stressed that a good functional outcome usually accompanies a good anatomical result. In comparative studies, bridging external fixator consistently achieved better anatomical results than remanipulation and cast management. The application of cast in these patients would lead to loss of reduction and a poor functional outcome.

In displaced intra articular fractures of distal radius, reduction is easy to achieve but difficult to maintain, due to intraosseous crushing, there is a void at the fracture site which can heal only after collapse, this collapse can be prevented by stabilizing either by packing cortico-cancellous bone graft in the void or by using metal to hold the fracture in place eg. External fixator.

External pins through metacarpals rigidly fixed by distractor to distal part of radius probably provides the best stabilization for lower end radius fracture. This produces traction effect on comminuted distal radius, this effect has been named ligamentotaxis. Fixed traction with ligamentotaxis minimizes the shortening that may result from resorption of bone at fracture site. The tensile distraction of radius helps healing of comminuted dorsal fragment of radius to occur without displacement.

External fixation also provides for retention of an anatomical reduction of the volar cortex obtained by traction with gentle manipulation. The distal fragments therefore are stabilized volarly, dorsal displacement is prevented and so is angulation. For an optional outcome selection of the patients is very important. Unreliable and poorly motivated patients are not the ideal candidates for external fixation.

Augmented External Fixation:

Distal radius fractures often require additional fixation methods after placement of the external fixator. The addition of K-wires to an external fixation construct has been proven in the lab to have increased rigidity.[63] This may be required if fracture reduction cannot be obtained by ligamentotaxis with the fixator alone, or if an excessive, nonphysiologic position of the wrist is needed for fracture reduction. In this latter case the fixator can be used as a provisional reduction tool. Often the fracture requires hyperflexion, ulnar deviation, and significant palmar translation. After this is achieved the reduction can be held with crossed K-wires (0.062"or 0.054"), one or two placed in the radial styloid and an additional pin placed in the ulnar corner of the radius.

Augmented fixation also can be beneficial during the postoperative course. With the presence of dual fixation, either the fixator or K-wires can be removed earlier if they become problematic. This can be especially helpful in the presence of a pin tract infection or to initiate early ROM therapy. The fixator can be removed early if there is pin irritation or infection and some of the smooth pins can be left in place as early motion is begun (Fig 4). Augmented external fixation avoids open exposures to the distal radius and becomes an attractive option for unstable distal radius fractures.

The ability of augmented external fixation to obtain good results has been well documented in the literature.[17,55,33]

Zanotti and Louis[7] prospectively studied the subjective, functional and radiographic outcomes of 20 patients with unstable distal radius fractures treated with external fixation alone or in combination with percutaneous pins. Outcomes were rated as excellent in one patient, good in 15 patients, fair in four patients, and poor in none. When analyzed by mechanism, patients who sustained a high-energy injury were more likely to require supplemental fixation (percutaneous pins). The authors concluded external fixation with supplemental K-wires is a viable treatment option for high-energy distal radius fractures.

In our results, all the younger patients have had good & excellent results while the older patients (i.e. 50 – 65 years) have developed the complications.

One patient (Female) developed pin loosening on the 4th week. Even the remaining elderly patients had only fair to poor results.

Hence in our study the external fixators proved to be effective in younger patients but not very effective in elderly patients.

Most of the patients recovered significant movement of the wrist & forearm with 2 weeks of physiotherapy.

In the literature the duration of fixation varies from 4 weeks to 10 weeks. In our series external fixation was maintained for 6 weeks. We had a high rate of excellent to good results and a low rate of complications.

External fixation is used to maintain axial length while reduction is attained by manipulation of fracture fragments with supplemental Kirschner wires and ligamentotaxis in intra-articular and extra-articular fracture patterns.[56,57]

However, external fixation alone is limited by the inability to directly reduce intra-articular fracture fragments in complex unstable fracture patterns. The advantages of open reduction and internal fixation include direct visualization and manipulation of the fracture fragments.[70]

Trumble et al.[80] stated that the degree to which articular step-off, gapping between fragments, and radial shortening can be improved with surgery correlates strongly with improved outcome. Hence, a treatment method that is more likely to achieve these goals will result in better function.

LOCKING COMPRESSION PLATE

A prospective randomised study by David H.Wei et al, compared with both external fixation and locking compression plate, fixation with a locked volar plate led to a more rapid improvement in subjective function.

This advantage over external fixation was evident at the six weeks time point, which may not be relevant because of the delay in initiating therapy when a spanning external fixator is in place. By three months, the patients with a volar plate not only had a higher level of subjective function than the patients treated with the other two techniques, but they also had a mean DASH score comparable with normative values.[87] By six months, all two surgical groups demonstrated excellent subjective functional scores, and at one year, the patients in the volar plate group had significantly better subjective function only when compared with those treated with a external fixation. Thus, the patients who had been treated with a volar plate had the distinct advantage of achieving normal subjective function three months earlier than the patients who had been managed with either external fixation.

Fixed angle volar plates for the fixation of distal radius fractures were introduced in the English literature by Orbay and Fernandez in 2002.[78]

Volar plating of dorsally angulated distal radius fractures, has become an increasingly common treatment option in more recent years.[81-87]

The volar side of the wrist has a large cross-sectional space and the pronator quadratus muscle can be used to cover a volar plate, thereby avoiding direct contact of the plate and screws with the flexor tendons, causing fewer complications and less hardware prominence.

Distal locking screws of the fixed angle plate prevent the distal fragments from collapsing dorsally which makes early mobilization possible. Volar fixed angle plates are pre-contoured to the anatomical shape of volar side of the distal radius.

The direction of the distal locking screws is either fixed by the plate design or it can be adjusted 5-10 degrees.[67]

Murakami et al[83] demonstrated that unstable distal radius fractures could be successfully treated with volar locking plate systems.

Wright et al [84] compared a volar locking plate to an external fixator in treating unstable distal radius fractures. They concluded that the use of a volar fixed-angle implant resulted in stable fixation of the distal articular fragments, allowing early postsurgical wrist motion. The PRWE and DASH scores in the volar plating group were better than those seen in the external fixator group.

Egol et al.[68] compared external fixation and locked volar plates in a prospective randomized manner and found an improved range of movement and radiological outcome at three and six months after locked plating.

CONCLUSIONS

In our series static external fixator was used to treat 15 patients with intra-articular distal end of radius fractures. Most of the cases in our series were of Frykman type VIII .

Mechanism of injury was road traffic accident in 11cases, fall from height 1 and fall on outstretched hand in 3 cases.

Two patients had associated injuries -One Lefort's fracture, another with ipsilateral supracondylar Femur fracture and one ankle bimalleolar fracture.

We inserted 2.5 mm Schanz pins, 2 in the proximal radius & two in the metacarpal [2nd & 3rd] involving 4 cortices. Engaging 4 cortices enhances the rigidity of the fixation and supplemental k-wire fixation where required.

External fixation was maintained for 6 weeks till the bony union is complete. For an optimal result, good anatomical reduction is necessary.

In our series locking compression plate was used to treat 15 patients with intra-articular distal end of radius fractures. Most of the cases were Frykmann type VIII.

Mechanism of injury was road traffic accident in 10 cases, and fall on outstretched hand in 5 cases.

The locking compression plate was applied after adequate reduction of the articular step-off, radial alignment under guidance of c-arm. We inserted the locking plate with good soft tissue coverage over the plate. The operative time was more as compared to the external fixator group. The range of motion gained was earlier than the external fixator group, even though the range of movements were not clinically significant.

SUMMARY

Static external fixators were used in 15 intra – articular fractures of distal end of radius in a prospective study. Fixator was maintained for a duration of 6 -8 weeks.

We had 2 excellent, 8 good, 3 fair and 2 poor result in our external fixator group. There was only 2 complications [10 %] one of pin loosening and one of shoulder hand syndrome.

We had 3 excellent,10 good ,1 fair,1 poor outcome in our LCP group. The fair and poor outcome was seen in elderly patients.

This series concludes that in LCP group had 20% excellent and 67%good outcomes as compared to external fixator group with 13% excellent and 53% good outcomes

In younger age group [<50], external fixation or ORIF locking compression plate consistently results in a favourable outcome in the management of intra-articular distal end of radius fractures.

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ANNEXURE I

INFORMED CONSENT

Mr/Mrs/Ms____

You are invited to participate in this study

TITLE OF THE STUDY: "EXTERNAL FIXATOR AND K-WIRE FIXATION VERSUS LOCKING COMPRESSION PLATE IN MANAGEMENT OF DISTAL - END RADIUS FRACTURES FRYKMANN'S TYPE VII AND VIII" -- A RANDOMISED CONTROLLED TRIAL.

PRINCIPAL INVESTIGATOR: BL0108001

Why am I being asked to take part in this study?

All patients attending in ortho O.P.D diagnosed to have distal-end radius fracture on clinical examination & diagnostic tests are eligible to be a part of this study. As you are diagnosed on initial evaluation to be a case of distal-end radius fracture so are eligible to be a part of the study & hence are asked to participate. the decision to participate is entirely your own.

Procedure	By thorough clinical evaluation according to proforma, by investigations
Risks	No life threatening risks
Benefits	No monetary benefits are offered to the patients. patients will be benefited by the outcome of the study in better understanding and treatment of the disease.
Outcome	To evaluate the efficacy locking compression plate versus external fixator & k-wire fixation in management of distal-end radius fractures.

What is the purpose of this study?

1) To study the efficacy locking compression plate versus external fixator & k-wire fixation in management of distal-end radius fractures.

2) To study the clinical outcome.

What are the procedures involved?

PROCEDURE OF EXTERNAL FIXATION AND K-WIRE FIXATION

The distal end radius intraarticular fracture will be reduced and fixed using k-wire , after which external fixator is applied. Mobilisation is started on the same day or next day. Follow-up radiographs will dictate the timing of external fixator removal.

BENEFITS

1. Early mobilisation
2. Maintains radial length.
3. Prevents recurrence of the deformity.

RISKS

1. Skin necrosis at pin site.
2. Pin tract infections.
3. Soft-tissue scarring
4. Injury to superficial sensory branch of radial nerve.
5. Loosening of the pins.

Procedure of locking compression plate

Locking compression plate is fixed using cortical screws. The forearm is immobilised on a splint. Radiographs are taken to confirm the reduction and fixation of fracture. Gradual mobilisation exercises are done. Skin sutures are removed on the tenth day. Patient comes for follow –up on 2nd, 4th and 6th week.

BENEFITS

1. Less incidence of infection.
2. Less incidence of implant failure.

RISKS

1. Infections.
2. Poor functional outcome.

Are there any benefits for taking part in this study?

No direct benefit is guaranteed to you from participating in our study. Your participation may benefit you and others suffering from same ailment in future, by helping us learn more about the treatment modalities. There are no financial incentives promised to you foe being a part of this study. It will help by reducing the pain, correcting the deformity & improving mobilisation at the fracture site.

What other options I have?

Taking part in this 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.

Will I be told about any new information that may affect my decision to participate?

I will tell of any important new findings that may change my willingness to continue to take part. If I choose not to take part in the study I will receive the standard treatment for patients with my condition.

What are the costs?

There will be no extra cost incurred by the participant. The participant will have to pay for the investigations which are part of the existing treatment protocol for this ailment.

Each prosthesis will cost around Rs: 4000/- to 5000/-.

What if I am physically injured as a result of my participation?

In event that you are physically injured as a result of your participation, emergency care will be available. There is however no commitment to provide any compensation for study related injury.

Will I be compensated for any of the expenses for participation in this study? As the subject voluntarily consents to be a part of the study, no compensation will be given. The patient can withdraw from the study anytime or can be removed from this study.

What about privacy & confidentiality?

All information collected about the subject during the course of the study will be kept confidential to the extent permitted by the law. The code numbers will identify the subject in this research record. Information from this study may be published but the subject's identity will be confidential in any publication.

Whom should I contact if I have any questions?

If any enquiries in the future or in case of study related injury or illness, you may contact following person.

CONSENT FORM

CONSENT TO PARTICIPATE IN RESEARCH STUDY:

I voluntarily agree to take part in this study by signing below. I may withdraw at any time. I am not giving up any of my legal rights by signing this form. My signature below indicated that I have read this entire consent form or it has been read to me, and had all my questions answered. I will be given a copy of this consent form.

Signature of the Participant or legally authorized representative.

Participant's Name	: ……………………………….
Signature	: ……………………………….
Name of the legally authorized representative	: ……………………………….
Signature	: ……………………………….
Witness's Name	: ……………………………….
Signature	: ……………………………….
Investigators name and Signature	: ……………………………….
Date and Place	: ……………………………….

ANNEXURE II

SCREENING PROFORMA

CASE NO: I.P. /O.P.D NO:

NAME:

SEX: PHONE NO: RES:

MOB:

ADDRESS:

ELGIBILITY CRITERIA

1. frykmann’s type VII & VIII.

2. Irrespective of age

PROFORMA/DATA COLLECTION INSTRUMENT (DCI)

1.CASE NO: 5. I.D. NO:

2.NAME: 6. D.O.A:

3.SEX: 7. D.O.S:

4.ADDRESS: 8. D.O.D:

9.COMPLAINTS:

10.MECHANISM OF INJURY

a. FALL ON OUTSTRETCHED HAND : YES/ NO

b. FALL FROM A HEIGHT : YES/ NO

c. ROAD TRAFFIC ACCIDENT: YES/ NO

d. OTHERS YES/ NO

e. ASSOCIATED INJURIES: YES/ NO

11.EXAMINATION

GENERAL PHYSICAL EXAMINATION:

a. PULSE: ________BEATS/MINUTE

b. BP: _____________MM/HG

B.ON PALPATION

1.TENDERNESS: YES / NO

2.DISPLACEMENT OF DISTAL FRAGMENT OF RADIUS

a. DORSAL: YES / NO

b. VOLAR: YES / NO

3. RELATIVE LEVEL OF STYLOID PROCESS OF RADIUS TO ULNA

a. AT SAME LEVEL YES / NO

b. HIGHER LEVEL YES / NO

4.MOVEMENTS - WRIST MOVEMENTS

a. DORSIFLEXION :___________°

b.PALMAR FLEXION :________ °

5.INFERIOR RADIOULNAR JOINT

a.SUPINATION: __________ ° YES / NO

b.PRONATION: __________ ° YES / NO

c.RADIAL DEVIATION: DEGREES YES / NO

d.ULNAR DEVIATION: DEGREES YES / NO

6.X-RAY FINDINGS

a.FRYKMANN'S TYPE: VII VIII

b.RADIAL LENGTH:

c.RADIAL TILT: YES/ NO

d.PALMAR TILT: YES/NO

7.METHOD OF TREATMENT:

ANAESTHESIA:
a.GENERAL YES /NO
b.REGIONAL YES /NO

8.SURGICAL INTERVENTION
A. ORIF WITH LOCKING COMPRESSION PLATE: YES/NO
OR

B.EXTERNAL FIXATOR AND K-WIRE FIXATION YES /NO

A

1. FOLLOW-UP OF EXTERNAL FIXATOR AND K-WIRE FIXATION

a. BRIDGING YES/NO

b. DYNAMIC YES/NO

2.POST – OPERATIVE X – RAY

a.AP VIEW:

b.LATERAL VEIW:

3.POST – OPERATIVE IMMEDIATE COMPLICATIONS

a.PAIN: YES/NO

b.SWELLING: YES/NO

c.NEUROVASCULAR DEFICIT YES/ NO

4. FOLLOW – UP: EXTERNAL FIXATOR AND K-WIRE FIXATION

SL.NO		1ST WEEK	2ND WEEK	6TH WEEK	8TH WEEK
a.	RECURRENCE OF DEFORMITY				
b.	PIN LOOSENING/PIN TRACT INFECTION				
c.	STIFFNESS OFHAND				
d.	EDEMA/SWELLING				
e.	MOVEMENTS OF SHOULDER,ELBOW,FINGERS				

5.REMOVAL OF EXTERNAL FIXATOR:

6.CLINICAL ASSESMENT:

a.PAIN: YES / NO

b.TENDERNESS: YES / NO

c.RESIDUAL DEFORMITY: YES / NO

d.RESIDUAL DISABILITY: YES / NO

e.RESTRICTION OF MOVEMENTS: YES / NO

f.DORSIFLEXION: _________ º YES / NO

g.PALMAR FLEXION:______ º YES/NO

h.SUPINATION:____________ º YES / NO

i.PRONATION: ____________ º YES/ NO

j.RADIAL DEVIATION:______ º YES/NO

k.ULNAR DEVIATION: _______º YES/NO

l.GRIP STRENGTH: GRADE 0 1 2 3 4 5

7.RADIOLOGICAL ASSESMENT:

a.AP VIEW:

b.LATERAL VIEW:

c.RADIAL LENGTH:

d.RADIAL TILT:

e.PALMAR TILT:

B

1.FOLLOW – UP OF LOCKING COMPRESSION PLATE

a.DORSAL APPROACH: YES/NO

b..VOLAR APPROACH YES/NO

2.POST – OPERATIVE X – RAY

a.AP VIEW:

b.LATERAL VEIW:

3.POST – OPERATIVE IMMEDIATE COMPLICATIONS

a.PAIN: YES/NO

b.SWELLING: YES/NO

c.NEUROVASCULAR DEFICIT YES /NO

4. FOLLOW – UP OF LOCKING COMPRESSION PLATE

SL NO.		1ST WEEK	2ND WEEK	3RD WEEK
a.	SEROUSDISCHARGE			
b.	PUS DISCHARG			
c.	WOUND GAPING			

5.CLINICAL ASSESMENT:

a.PAIN: YES/NO

b.,TENDERNESS: YES/NO

c.RESIDUAL DEFORMITY: YES/NO

d.RESIDUAL DISABILITY: YES/NO

e.RESTRICTION OF MOVEMENTS: YES/NO

f.DORSIFLEXION:__________ º YES/NO

g.PALMAR FLEXION:_______ º YES/NO

h.SUPINATION: ____________ º YES /NO

i.PRONATION: ____________ º YES/NO

j.RADIAL DEVIATION: _____ º YES/NO

k.ULNAR DEVIATION: ______º YES/NO

l.GRIP STRENGTH: 0 1 2 3 4 5

6.RADIOLOGICAL ASSESMENT:

a.AP VIEW:

b.LATERAL VIEW:

c.RADIAL LENGTH:

d.DORSAL TILT: ____________ º YES/NO

e.PALMAR TILT:____________ º YES/NO

Signature of examiner **Signature of patient** **Signature of Guide**

DEMERIT SCORING SYSTEM OF SAITO

1.	Subjective evaluation		
	excellent	No pain,no disability,no limitation of motion	0
	good	Occasional pain,no disability,slight limitation of motion	2
	Fair	Occasional pain,no particular disability,some limitation of motion,feeling of weakness in wrist, activities slightly restricted	4
	poor	Pain,disability,limitation of motion,activites markedly restricted	6
2.	Objective evaluation		
a.	Residual deformity	0 ±2 mm	1
	Ulnar variance	0 ±2 mm	1
	Palmar tilt Radial tilt	11± 10 ^{o} 23± 10 ^{o}	1 1
b.	Range of movements (range 0-5)	Minimal for normal function	
	Dorsiflexion Palmarflexion Ulnardeviation Radialdeviation Supination Pronation Pain in distal radioulnar joint	45º 30º 15º 15º 50º 50º	1 1 1 1 1 2 1
c.	Grip power	60% or less than opposite side	
	dominant	<1/2 power of opp hand < 2/3 power of opp hand	1 2
	Non-dominant	<1/2power of opp hand <2/3 power of opp hand	1 2
d.	Arthritic changes	Irregularity of articular surface sharpening of articular margin	
	none		0
	minimal	Irregularity of articular surface sharpening of articular margin	1
	moderate	Narrowed joint	2

		space,osteophytes	
	severe	Marked osteophytes,ankylosis	3
e.	complications		
	Nerve complication		1-3
	Stiff fingers		1-2
	Ruptured tendons		1-2
	Final results	Ranges of movement	
	excellent		0-2
	Good Fair		3-8 9-20
	poor		>21

CASE NO: 8 E

AP VIEW LATERAL

CHECK X-RAY

6 MONTHS FOLLOW-UP

6 MONTHS FOLLOW-UP

Case no: 14 G

AP VIEW

LAT

CHECK XRAY

AP

LATERAL

AP LATERAL

6 MONTHS FOLLOW-UP

6 MONTHS FOLLOW-UP

CASE NO: 15 F

AP VIEW

LATERAL

CHECK XRAY

6 WEEKS

6 months follow-up

CASE 4   P

AP VIEW

LATERAL

CHECK X-RAY

6 MONTHS FOLLOW-UP

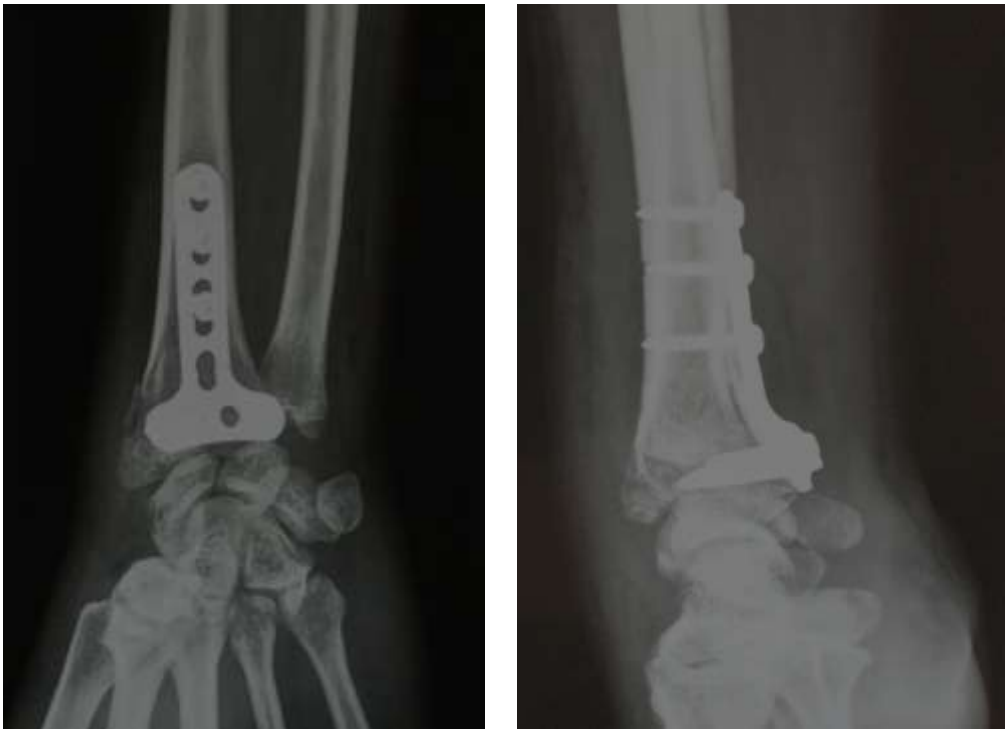
LCP CASES

CASE 8

AP VIEW

LATERAL

CHECK XRAY



6 MONTHS FOLLOW –UP

6 MONTHS FOLLOW-UP

Case 1 G

AP VIEW LATERAL

CHECK XRAY

AP LATERAL

6 MONTHS FOLLOW-UP

6 MONTHS FOLLOW-UP

CASE NO : 15 F

AP

LATERAL

CHECK X-RAY AP

LATERAL

AP LATERAL

6 MONTHS FOLLOW-UP

6 MONTHS FOLLOW-UP

CASE 6   P

AP

LATERAL

AP

LATERAL

CHECK X-RAY

AP

LATERAL

6 MONTHS FOLLOW-UP

6 MONTHS FOLLOW-UP

LOCKING COMPRESSION PLATE

CASE NO	AGE	SEX	I.P.NO	DOA	DOS	DOD	LATERALITY	FRYKMAN	MOI	DF	PF	RD	UD	SUP	PRO	RAD LENGTH	ASSOC INJ	ARTHRITIS	6 WEEKS	3 MONTHS	6 MONTHS	RESULTS
1	58	F	292516	10/10/2008	10/10/2008	26/10/2008	R	VIII	FOSH	80	80	15	30	80	80	-1	-	N	2	2	0	EXCELLENT
2	65	F	294334	20/10/2008	21/10/2008	03/11/2008	R	VII	FOSH	80	75	15	30	70	70	-2	-	N	4	2	2	GOOD
3	51	M	294955	27/11/2008	27/11/2008	10/12/2008	R	VIII	RTA	70	70	15	30	75	75	-1	-	N	4	2	2	GOOD
4	42	M	311603	01/08/2009	01/08/2009	13/08/2009	L	VIII	RTA	70	70	15	25	70	70	-1	-	N	4	2	2	GOOD
5	23	F	328365	20/08/2009	22/08/2009	02/09/2009	R	VII	RTA	70	70	15	20	70	70	-1	-	N	6	6	6	GOOD
6	55	M	330933	19/08/2009	19/08/2009	30/09/2009	L	VIII	FOSH	45	40	10	10	50	45	-4	-	N	6	4	4	POOR
7	29	M	330793	03/09/2009	03/09/2009	14/09/2009	R	VII	RTA	60	50	15	15	60	50	-2	-	N	4	2	2	FAIR
8	48	M	332885	26/10/2009	26/10/2009	10/11/2009	R	VIII	RTA	75	75	15	30	70	70	-1	-	N	4	2	2	GOOD
9	24	F	339648	05/11/2009	05/11/2009	18/11/2009	R	VII	RTA	80	80	15	30	80	80	-1	-	N	2	2	0	EXCELLENT
10	58	M	341006	18/11/2009	21/11/2009	30/11/2009	L	VIII	RTA	75	70	15	25	75	70	-2	-	N	4	2	2	GOOD
11	45	M	342782	10/02/2010	10/02/2010	24/02/2010	L	VII	RTA	75	70	15	20	75	70	-1	-	N	4	2	2	GOOD
12	24	M	353390	01/03/2010	01/03/2010	15/03/2010	L	VII	RTA	70	70	15	25	75	75	-2	-	N	2	2	0	EXCELLENT
13	40	F	357770	23/03/2010	24/03/2010	10/04/2010	R	VIII	RTA	70	70	15	30	70	70	-2	-	N	4	4	2	GOOD
14	50	F	358666	23/03/2010	24/03/2010	10/04/2010	R	VII	FOSH	70	70	15	30	75	70	-2	-	N	4	4	2	GOOD
15	54	M	330793	08/03/2010	08/03/2010	20/03/2010	R	VIII	FOSH	75	75	15	30	75	70	-1	-	N	4	2	2	GOOD

EXTERNAL FIXATOR

CASE NO	AGE	SEX	I.P.NO	DOA	DOS	DOD	AFF EXT	FRYKMANN TYPE	MOI	DF	PF	RD	UD	SUP	PRO	RAD LENGTH	ASSOC INJ	DOF	ARTRITIS	6 WEEKS	3 MONTHS	6 MONTHS	RESULTS
1	50	F	301453	16/12/2008	16/12/2008	24/12/2008	R	VIII	FOSH	70	60	15	20	75	75	-1		6	N	4	2	2	GOOD
2	44	M	303673	18/01/2009	21/01/2009	30/01/2009	L	VII	RTA	80	80	15	30	80	80	-1		6	N	4	2	0	EXCELLENT
3	40	M	306300	08/02/2009	08/02/2009	18/02/2009	R	VIII	RTA	75	75	15	30	75	75	-2		6	N	4	2	2	GOOD
4	62	M	306410	16/02/2009	18/02/2009	26/02/2009	L	VII	FOSH	50	50	15	15	75	70	-1		6	N	4	4	4	FAIR
5	24	M	317486	12/03/2009	12/03/2009	28/03/2009	L	VIII	RTA	75	70	15	30	70	70	-1		6	N	4	2	2	GOOD
6	42	M	330744	18/08/2009	19/08/2009	24/08/2009	L	VIII	RTA	70	70	15	30	70	70	-1		6	N	4	2	2	GOOD
7	54	M	339836	01/11/2009	01/11/2009	15/11/2009	R	VII	RTA	75	70	15	20	70	70	-1	FEMUR #	6	N	4	2	2	GOOD
8	26	M	340392	18/11/2009	18/11/2009	30/11/2009	R	VIII	RTA	70	70	15	30	70	70	-1		6	N	4	2	2	GOOD
9	45	M	342782	22/01/2009	22/01/2009	05/02/2009	R	VII	RTA	80	80	15	30	70	70	-1		6	N	4	2	0	EXCELLENT
10	39	M	350929	25/01/2010	25/01/2010	20/02/2010	L	VIII	FFH	70	70	15	15	60	60	-3	ANKLE#	7	N	4	4	4	FAIR
11	38	M	351389	24/02/2010	24/02/2010	30-2-2010	L	VIII	RTA	70	70	15	15	60	50	-3	LEFORT#	6	N	6	4	4	FAIR
12	30	M	352304	01/05/2010	03/05/2010	20/05/2010	L	VIII	RTA	45	45	10	10	50	50	-3		6	N	6	6	6	POOR
13	22	M	365015	01/05/2010	01/05/2010	20/05/2010	R	VII	RTA	75	75	15	20	70	70	-2		6	N	4	2	2	GOOD
14	45	F	368024	30/05/2010	30/05/2010	12/06/2010	L	VII	FOSH	75	75	15	20	75	70	-1		8	N	4	4	2	GOOD
15	45	M	382050	30/08/2010	30/08/2010	10/09/2010	L	VII	RTA	50	50	10	10	70	70	-3		6	N	6	6	6	POOR