"STUDY OF MANAGEMENT OF UNSTABLE FRACTURE OF DISTAL END RADIUS USING EXTERNAL FIXATOR IN ADULTS"

By

Dr. M. C. VINOD KUMAR REDDY

DISSERTATION SUBMITTED TO SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, KOLAR, KARNATAKA

In partial fulfillment of the requirements for the degree of

MASTER OF SURGERY

IN

ORTHOPAEDICS

Under the Guidance of

Dr. P.V. MANOHAR
Professor & HOD

DEPARTMENT OF ORTHOPAEDICS,
SRI DEVARAJ URS MEDICAL COLLEGE,
TAMAKA, KOLAR-563101

MAY 2015

SRI DEVARAJ URS MEDICAL COLLEGE,
TAMAKA, KOLAR-563101

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis **entitled "STUDY OF MANAGEMENT OF UNSTABLE FRACTURE OF DISTAL END RADIUS USING EXTERNALFIXATOR IN ADULTS"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. P. V. MANOHAR, Professor & HOD**, Department of Orthopaedics, Sri Devaraj Urs Medical College & Research center, Tamaka, Kolar.

Date: **Dr. M. C. VINOD KUMAR REDDY**

Place: Kolar

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION, TAMAKA, KOLAR, KARNATAKA

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled **"STUDY OF MANAGEMENT OF UNSTABLE FRACTURE OF DISTAL END RADIUS USING EXTERNALFIXATOR IN ADULTS"**is a bonafide research work done by **Dr. M. C. VINOD KUMAR REDDY** in partial fulfillment of the requirement for the Degree of MASTER OF SURGERY in **ORTHOPAEDICS**

Date:

Place: Kolar

Signature of the Guide

Dr. P. V. MANOHAR

Professor & HOD,

Department of Orthopaedics,

Sri Devaraj Urs Medical College,

& Research Center, Tamaka, Kolar.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, TAMAKA, KOLAR, KARNATAKA

ENDORSEMENT BY THE HOD, PRINCIPAL / HEAD OF THE INSTITUTION

This is to certify that the dissertation entitled **"STUDY OF MANAGEMENT OF UNSTABLE FRACTURE OF DISTAL END RADIUS USING EXTERNALFIXATOR IN ADULTS"** is a bonafide research work done by **Dr. M. C. VINOD KUMAR REDDY** under the guidance of **Dr. P. V. MANOHAR,** Professor & HOD, Department Of Orthopaedics

Dr. P.V.MANOHAR
Professor & HOD
Department of General Surgery,
Sri Devaraj Urs Medical College,
& Research Center, Tamaka, Kolar

Dr. M. B. SANIKOP
Principal,
Sri Devaraj Urs Medical College
& Research Center, Tamaka, Kolar

Date:
Place: Kolar

Date:
Place: Kolar

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, TAMAKA, KOLAR, KARNATAKA

ETHICAL COMMITTEE CERTIFICATE

This is to certify that the Ethical committee of Sri Devaraj Urs Medical College & Research Center, Tamaka, Kolar has unanimously approved

Dr. M. C. VINOD KUMAR REDDY

Post-Graduate student in the subject of

ORTHOPAEDICS *at Sri Devaraj Urs Medical College, Kolar*

to take up the Dissertation work entitled

"STUDY OF MANAGEMENT OF UNSTABLE FRACTURE OF DISTAL END RADIUS USING EXTERNALFIXATOR IN ADULTS"

to be submitted to

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, TAMAKA, KOLAR, KARNATAKA,

Date:

Place: Kolar

Member Secretary

Sri Devaraj Urs Medical College,

& Research Center,

Tamaka, Kolar–563101

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, TAMAKA, KOLAR, KARNATAKA

COPY RIGHT

DECLARATION BY THE CANDIDATE

I hereby declare that the Sri Devaraj Urs Academy of Higher Education and Research Center, Kolar, Karnataka shall have the rights to preserve, use and disseminate this dissertation/thesis in print or electronic format for academic /research purpose.

Date:

Place: Kolar **Dr. M. C. VINOD KUMAR REDDY**

ACKNOWLEDGEMENT

Ever since I began this dissertation, innumerable people have participated by contributing their time, energy and expertise. To each of them and to others whom I may have omitted through oversight, I owe a debt of gratitude for the help and encouragement.

I am deeply indebted and grateful to my esteemed teacher, mentor and guide **Dr. P. V. MANOHAR ,** *Professor and H.O.D, Department of Orthopaedics, Sri Devaraj Urs Medical College, Tamaka, Kolar, for his guidance, support and constant encouragement throughout the period of this study. His knowledge and experience has guided, molded and infused in me a sense of confidence to overcome hurdles both personally and academically..*

I am highly grateful to **Dr. M. B. Sanikop,** *Principal, Sri Devaraj Urs Medical College, Tamaka, Kolar, for permitting me to conduct this study.*

I also acknowledge my debt to **Dr. B. Shaikh Nazeer, Dr. N. S. Gudi,** *and* **Dr. Arun. H. S,** *Department of Orthopaedics, Sri Devaraj Urs Medical College, Tamaka, Kolar, who gave me moral support and guidance by correcting me at every step.*

I remain thankful to all my Assistant Professors and Lecturers for their support and encouragement. I acknowledge my sincere thanks to all my co-post graduates for their help and support at every step throughout my study.

All the non-medical staff of Department of Orthopaedics, Sri Devaraj Urs Medical College, Tamaka, Kolar, have also made a significant contribution to this work, to which I express my humble gratitude.

I am thankful to the Department of Anaesthesia, Sri Devaraj Urs Medical College, Tamaka, Kolar, for their valuable co-operation.

*I am very much thankful to my parents, **Mr. M. KESAVA REDDY, Mrs.ARAVINDHA** for their love, blessings and invaluable help. They have been my strength all the time and their wise advice, prayers and sacrifices have done wonders for me.*

*I also thank my friends **Dr. NAGARJUN. A, Dr. ANVESH, Dr. PRATAP, Dr. AJAY** for their love and support. They have contributed to the exchange of ideas resulting in the precise presentation of the collected information.*

*Last, but not the least, I thank the Almighty and **my patients** for providing me the opportunity to carry out my study.*

Dr. M. C. VINOD KUMAR REDDY

ABSTRACT

Background:

Preservation of the articular congruity is the principle prerequisite for successful recovery following distal radius fractures. The best method of obtaining and maintaining an accurate restoration of articular anatomy however, remains a topic of considerable controversy. External fixation as a method of treatment for distal end of radius fracture has more than 60 yrs of documented clinical experience. The main aim of this study is to evaluate the results obtained by treatment of distal end radius fractures by external fixation.

Objectives:

1. To stabilize and assess the efficiency of external fixators in the management of unstable distal end radius fractures.
2. To assess anatomical and functional results in patients treated with external fixator by modified Gartland and Werley De merit point system.

MATERIALS AND METHODS:

This study is a hospital based prospective study centered in Department of Orthopaedics at R.L Jalappa Hospital and Research Centre, Kolar, from Nov 2012 to Apri 2014 in which 30 patients with Unstable distal end radius fractures are treated with external fixator.

Results:

Patients were regularly followed-up post-operatively. Thirty cases were available for follow up. Excellent results were seen in 10 patients, good results in 16 patients, fair results in 2 patients and poor results in 1 patients.

Interpretation & Conclusion:

- External fixation and ligamentotaxis provides better functional and anatomical results in comminuted intra-articular fractures. The successful use of external fixator for distal end radial fractures requires careful assessment of fracture pattern, appropriate patient selecting, meticulous surgical techniques appropriate choice of fixation, judicious augmentation with internal fixation and bone grafting, careful post operative monitoring and aggressive early institution of rehabilitation. The final functional result of treatment of distal radius fractures not only depends on the anatomical restoration of the articular surface but also on the associated soft tissue injuries and articular damage.

Keywords: Distal radius fracture; External fixation, Ligamentotaxis; Intra-articular fractures; Distal end radius.

LIST OF ABBREVIATIONS

TFCC	:	Triangular Fibrocartilage Complex
EPL	:	Extensor Pollicis Longus
RSD	:	Reflex Sympathetic Dystrophy
DRUJ	:	Distal Radioulnar Joint
POP	:	Plaster of Paris
RTA	:	Road Traffic Accidents
DF	:	Dorsi Flexion
PF	:	Palmar Flexion
UD	:	Ulnar Deviation
RD	:	Radial Deviation

\\

TABLE OF CONTENTS

LIST OF TABLES

LIST OF GRAPHS

LIST OF FIGURES

INTRODUCTION

Dr. Abraham Colles, in reference to fractures of the distal aspect of the radius, stated: "One consolation only remains, that the limb will at some remote period again enjoy perfect freedom in all its motions, and be completely exempt from pain; the deformity, however, will remain undiminished throughout life." In 1814, when Dr. Colles described the fracture, there was no anesthesia (1846), no aseptic surgery (1865), no radiography (1895), no electricity (1879).

Incidence of fractures of distal radius are increasing due to more geriatric population and road traffic accidents. At the same time surgical treatment options are also modified continuously[1].

Many fractures of the distal aspect of the radius are relatively uncomplicated and are effectively treated by closed reduction and immobilization in cast. But these distal radius fractures are articular injuries resulting in disruption of both the radiocarpal and radioulnar joints. About 50% of the metaphyseal fractures have intra articular extension to radiocarpal or distal radioulnar joint. In majority of cases prompt detection of articular fragments displacement, stability, and reducibility provides a rational basis of optimal management of these complex distal end radius fractures.

Intra-articular fractures can jeopardize the integrity of the articular congruence and /or kinematics of these articulations. Distal radius fractures especially the high energy fractures are often associated with poor results and high complication rates, In order to treat these fractures optimally, we must understand the extent of displacement, the degree of articular disruption, the stability and reducibility of each fracture as well as any concurrent injury to adjacent nerves, tendons or carpal structures, must be assessed carefully[2,3].

The fundamental goal of the treatment of the distal radius fracture is restoration of normal or near normal alignment and articular congruity. Although reduction can be achieved easily, maintenance of the reduction until healing results in loss of joint motion either secondary to immobilization or malunion (the cancellous bone unites with collapse and loss of radial length). To overcome these disadvantages of conservative methods, various modalities of surgical fixations evolved, including external fixation[4].

Anderson and O'Neil, were the first to introduce the use of external fixation in the treatment of these fractures. Since then there is a trend to use external fixators in management of these fractures as these give improved results both functionally as well as improved anatomic reconstruction.

Ligamentotaxis is the term used to emphasize that, for traction to be effective it must be balanced by counter traction provided by ligaments and soft tissue surrounding the bone. The pull and the counter pull restore the length and guides alignment of the fracture fragments, which are otherwise difficult to control. This tissue tension can be maintained by external fixator or by a distracter[5].

The successful use of external fixation in the management of unstable intra-articular fractures necessitates careful assessment of the fracture pattern, appropriate patient selection, meticulous surgical technique, appropriate choice of fixation devices, careful post-operative monitoring and aggressive early rehabilitation[6].

OBJECTIVES

1. To stabilize and assess the efficiency of external fixators in the management of unstable distal end radius fractures.

2. To assess anatomical and functional results in patients treated with external fixator by modified Gartland and Werley De merit point system.

HISTORY

In 1814, Abraham Colles, an Irish Surgeon described in detail the dorsally displaced distal radius fracture that bears his name. Colles fracture is also known as the Pouteau's fracture. His description of a non-articular fracture occurring 4 centimeters proximal to the radio-carpal joint was meant to counter-act the than belief that all injuries to the wrist were dislocations. The term has since been generalized to include any dorsally displaced fractures regardless of the joint involvement or comminution.

There are few things in surgery which are actually new, and this applies to external fixation. Hippocrates in about 400 BC wrote about a simple external fixator. The first use of "pins" is credited to Malgaigne who, in 1840, created a simple metal pin in a leather strap for the percutaneous pin treatment of tibial fractures. He also made an external fixator for patella fractures he called a "griffe", or "claw." Malgaigne's pin became popular, according to Burny (1965), and was improved upon by others, including Bonnet,Delltheil, Roux, and Ollier.

Parkhill in 1894 in the US treated fractures, nonunions, and mal unions by threaded pins implanted into bone fragments and externally connected with two plates.

Lambotte, a Belgian surgeon, was the first to develop a device specially designed for external fixation, in 1902. For the first time, the device allowed the placement of the pins in any needed direction and the pins were connected to the rod by adjustable clamps. The fracture had to be reduced prior to application of the external fixator.

Lambotte is also credited with developing the first self-tapping threaded pin.

Shanz, Reidel, and Anderson used nails and screws in conjunction with casts and developed the idea of non-parallel pins for firmer control of bone fragments. The first adjustable external fixator was by Stader and was originally used in dogs, and the first adjustable external fixator for the distal radius was by Roger Anderson in 1934. The Hoffmann external fixator came two years later in 1936.

ANATOMY OF WRIST [7,8,9]

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. 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 inter osseous 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 17thand 19thyears respectively. A fourth centre sometimes appears in the tuberosity about the 14^{th} or 15th year.

Distal end 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, posterolateral 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 four main centres, one each in the shaft and distal end and two in the olecranon. Ossification begins in the mid shaft about the eighth fetal week, and extends rapidly. In the fifth (females) and sixth (males) years, a centre appears in the distal end, and extends into the styloid process. The distal epiphysis unites with the shaft in the seventeenth year in females, eighteenth in males.

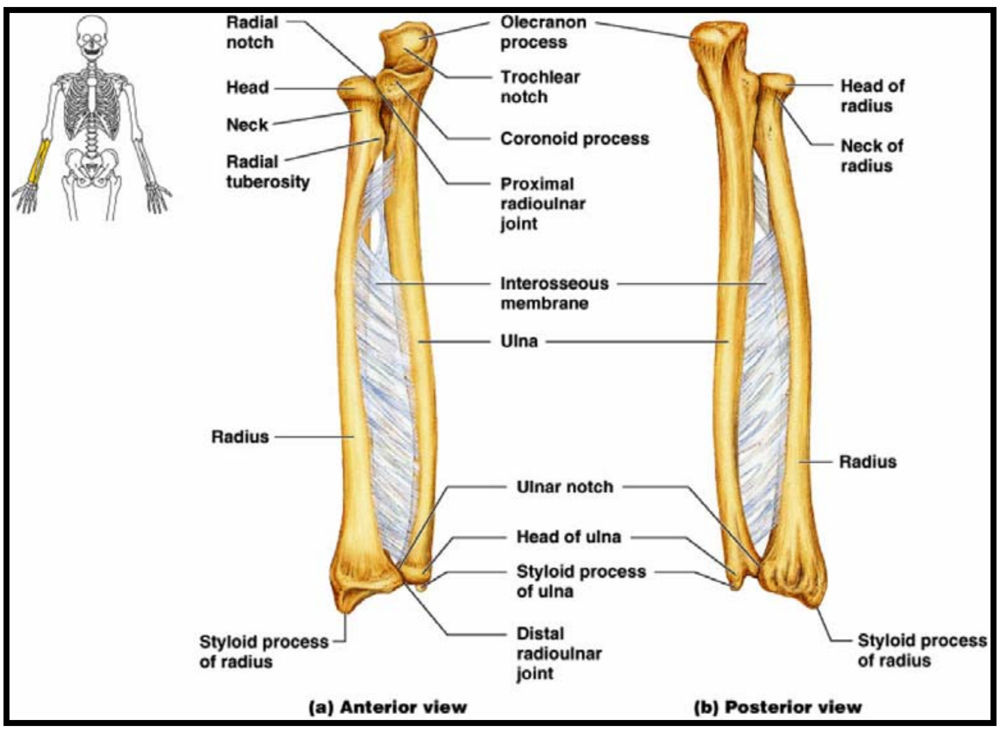


Fig 1 : Anatomy of radius and ulna

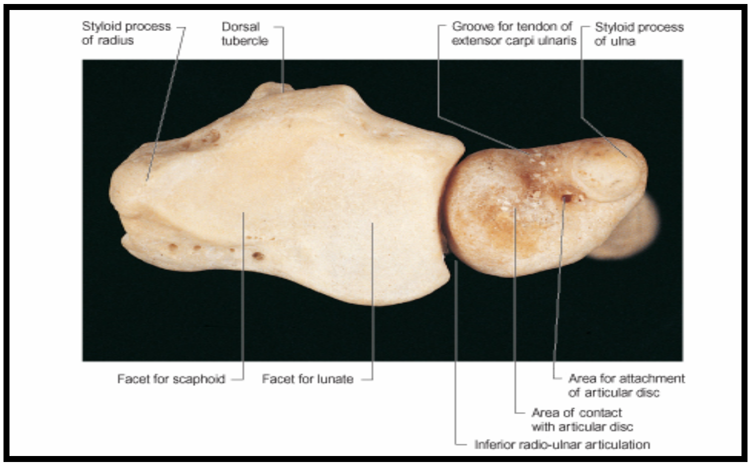


Fig 2 : Articular surface of radius and ulna

The carpal bones:

The carpus contains 8 bones in proximal and distal rows. Proximally, in lateral to medial border, are the scaphoid, lunate, triquetrum and pisiform bones; in the distal row are the trapezium, trapezoid, capitate and hamate bones. The pisiform articulates with the palmar surface of the triquetrum, 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 triquetrum. The humulus 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 scaphoid 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 trapezium 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 triquetrum and pisiform, are attachments of the radiocarpal, intercarpal and carpometacarpal ligaments.

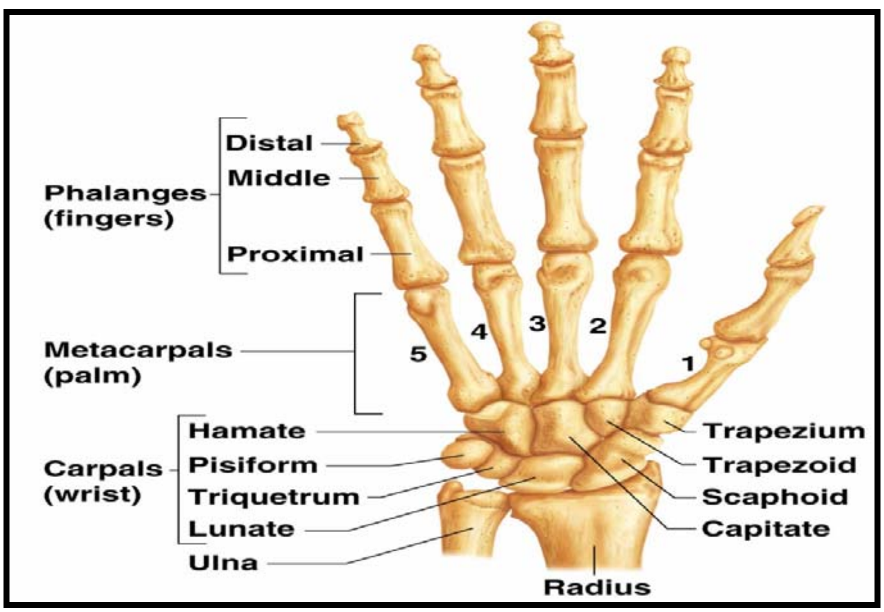


FIG 3 Anatomy of carpal bones

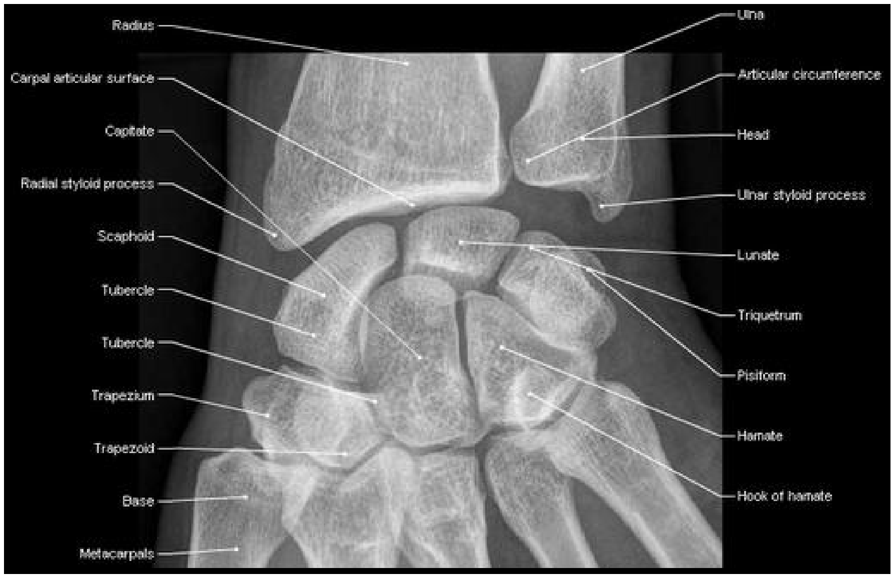


FIG 4 X RAY showing carpal bones

JOINTS

RADIOCARPAL (WRIST) JOINT

The radiocarpal joint is a synovial biaxial and ellipsoid joint formed by articulation of the distal end of the radius and the triangular articular disc with the scaphoid, lunate and triquetrum. In the neutral position of the wrist, only the scaphoid and lunate are in contact with the radius and articular disc, the triquetrum comes into apposition with the disc only in full adduction of the wrist joint. The radial articular surface and distal discal surface form an almost elliptical, concave surface with a transverse long axis. 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. The proximal articular surfaces of the scaphoid, lunate and triquetrum, and their interosseous ligaments, form a smooth convex surface which is received into the proximal concavity.

The fibrous capsule is lined by synovial membrane which is usually separate from that of the distal radio-ulnar and intercarpal joints. A protruding prestyloid recess (recessus sacciformis), anterior to the articular disc, is present and ascends close to the styloid process. The recess is bounded distally by a fibrocartilaginous meniscus, which projects from the ulnar collateral ligament between the tip of the ulnar styloid process and the triquetrum; 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 joint is supplied by branches of the anterior interosseous artery, anterior and posterior carpal branches of the radial and ulnar arteries, palmar and dorsal metacarpal arteries and recurrent rami of the deep palmar arch.

The joint is innervated by the anterior and posterior interosseous nerves.

WRIST LIGAMENTS

Wrist ligaments situated between the fibrous and synovial layers of the wrist joint are termed intra capsular, while those lying superficial to the fibrous layer are extra capsular. Almost all ligaments of the wrist actually lie within the joint capsule and the only exceptions are the flexor and extensor retinaculae and the pisotriquetral ligament.

The intracapsular ligaments appear to blend one into another and the edges of the ligaments may not be distinct or discrete.The ligaments are further classified into extrinsic and intrinsic named ligaments

EXTRINSIC LIGAMENTS:

Extrinsic ligaments connect the carpus with the forearm bones. The extrinsic ligaments as a group tend to be longer than the intrinsic ligaments. They are approximately one-third as strong but easier to repair following rupture.

EXTRINSIC PALMAR CARPAL LIGAMENTS:

When the synovial lining of the carpal tunnel is dissected away, two V-shaped ligamentous bands are visible with their apices lying distally. The limbs of the 'V' take origin from the radius and ulna respectively: the apex of one 'V' attaches to the distal row and that of the second 'V' to the proximal row.

Radioscaphocapitate ligament:

The radioscaphocapitate ligament originates from the radial styloid and the palmar lip of the radius. It courses distally and is then described by some authors as having three parts. The first is the most radial and inserts onto the lateral aspect of the waist of the scaphoid (radial collateral ligament). The second continues as part of the distal 'V' and inserts onto the distal pole of the scaphoid. The third passes over the proximal pole of the scaphoid towards the mid carpus and blends with the fibres originating from the ulnar side-part of the triangular fibrocartilage complex-to form the arcuate ligament over the palmar aspect of the capitate.

Long radiolunate ligament:

The long radiolunate ligament takes origin adjacent to the radioscaphocapitate ligament on the palmar lip of the radius. It passes over and supports the proximal pole of the scaphoid before inserting into the palmar horn of the lunate

Radioscapholunate (ligament of Testut):

Histological studies have shown the radioscapholunate ligament is not a true ligament because it contains neurovascular structures which supply the scapholunate interosseous membrane and is covered by a thick synovial lining. However it a visible landmark inside the wrist joint when undertaking wrist arthroscopy.

Short radiolunate ligament:

The short radiolunate ligament is part of the proximal 'V'. It arises from the palmar lip of the lunate fossa of the radius and passes directly to the palmar horn of the lunate. To the ulnar side its fibres blend with those of the palmar triangular fibrocartilage complex as these also pass to their insertion on the lunate. This ligament contributes to the stability of the lunate

Ulnolunate ligament:

The ulnolunate ligament originates from the palmar aspect of the ulna adjacent to the short radiolunate ligament and inserts onto the palmar horn of the lunate. Part of this fibre complex arches radially and blends with part of the radioscaphocapitate complex, forming the arcuate ligament

Ulnotriquetral (ulnar collateral) ligament:

The ulnotriquetral ligament arises from the palmar aspect of the ulna and inserts into the medial aspect of the triquetrum. It continues distally to a further attachment to the medial aspect of the hamate. It is generally thought that the ulnolunate and ulnotriquetral ligaments take some origin from the marginal ligament of the TFCC as well

EXTRINSIC DORSAL CARPAL LIGAMENTS:

The dorsal wrist ligaments are comparatively thin. They are reinforced by the floor and septa of the fibrous tunnels for the six dorsal compartments. The extrinsic dorsal carpal ligaments and the intrinsic dorsal intercarpal ligaments have a 'Z-shaped' configuration

Dorsal radiolunotriquetral ligament:

The dorsal radiolunotriquetral ligament is a true intracapsular ligament. It is the only extrinsic ligament on the dorsum of the carpus and has superficial and deep components.

The superficial part connects the radius and triquetrum, and the deep part connects the radius, lunate and triquetrum.

INTRINSIC LIGAMENTS:

Intrinsic ligaments of the wrist are attached to carpal bones. They are stronger and shorter than extrinsic ligaments and are connected with the extrinsic ligament complexes by interdigitating fibres. Rupture of one or more intrinsic ligaments frequently leads to a clinical instability of the carpus. The intrinsic ligaments are subdivided into ligaments which connect the carpal bones of the proximal and distal rows respectively and those which connect the rows by crossing over the midcarpal joint.

Proximal row interosseous ligaments

The scapholunate and lunotriquetral ligaments are clinically and biomechanically important structures. In the sagittal plane they have an approximately horseshoe-shape configuration with palmar, midcarpal and dorsal components. The scapholunate ligament contains short transverse fibres connecting the dorsal aspect of the respective bones and more obliquely oriented fibres connecting the palmar aspect.

The lunotriquetral ligament has similar dorsal, midcarpal interosseous and palmar components, but the fibres of the dorsal and palmar components are similarly rather than differentially oriented, which precludes the same pattern of preferential movement as occurs between the lunate and scaphoid.

Distal row interosseous ligaments

The distal row interosseous ligaments are powerful ligaments between the capitate, hamate, trapezium and trapezoid, with an important stabilizing function for the distal carpal row

Palmar midcarpal ligaments

Antero-laterally lies the fan-shaped palmar scaphocapitate-trapezoid ligament which originates from the scaphoid tuberosity and is thought to be an important stabilizer of the scaphoid

Dorsal midcarpal ligaments

The dorsal intercarpal ligament assists in stabilization of the proximal carpal row. It arises from the trapezoid and distal pole of scaphoid, and passes across the dorsal horn of the lunate to be attached to the triquetrum

PART A: **1.** Radioscaphocapitate ligament. **2.** Long radiolunate ligament. **3.** Palmar lunotriquetral interosseous ligament. **4.** Palmar triquetrohamate and triquetrocapitate ligaments. **5/6.** Palmar distal row interosseous ligaments.

PART B: **7.** Dorsal radio-ulnar ligament. **8.** Dorsal radiolunotriquetral ligament. **9.** Dorsal intercarpal ligament. **10.** Dorsal distal row interosseous ligament. **11.** Scaphotrapeziotrapezoidal ligament.

Fig 5 Anatomic dissection of the major extrinsic and intrinsic wrist ligaments

WRIST MOVEMENTS

The movements at the radiocarpal and intercarpal joints are considered together since they are both involved in all movements as well as being acted upon by the same muscles. Active movements are flexion (85°), extension (85°), adduction (ulnar deviation) (45°), abduction (radial deviation) (15°) and circumduction

Flexion : Muscles responsible

Flexor carpi ulnaris.

Flexor carpi radialis

Palmaris longus

Assisted by: Flexor digitorum superficialis

Flexor digitorum profundus.

Abductor pollicislongus

Extension : Extensor digitorum.

Extensor digitimiinimi.

Extensor indices.

Extensor pollicis longus.

Adduction : Flexor carpi ulnaris

Extensor carpi ulnaris

Abduction : Flexor carpi radialis.

Extensor carpi radialislongus and brevis.

Abductor pollicislongus and extensor pollici Brevis

THE DISTAL RADIO ULNAR JOINT

This is a uni axial 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 recessus 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

BIOMECHANICS OF THE WRIST[8]

Wrist motion is composed of flexion, extension and ulnar deviation at the radiocarpal joint and axial rotation around the distal radioulnar joint. The radiocarpal articulation acts as a universal joint, allowing a small degree of intercarpal motion around the longitudinal axis related to the rotation of individual carpal bones. The forearm accounts for the most rotation and supplies the hand with the strength necessary to apply the necessary torque. The motion of the radiocarpal joint is flexion-extension of near equal proportion [170 degrees each] and radial and ulnar deviation of 20 degrees and 40degrees respectively. This amount of motion is possible as a result of complex arrangements between the two carpal rows. During flexion and extension, each carpal row angulates in the same direction with nearly equal amplitude and in a synchronous fashion. During radio-ulnar deviation, however, the proximal row exhibits a secondary angulation in the sagittal plane to the synchronous motion occurring in the coronal plane. Radial deviation induces flexion of the obliquety situated scaphoid as the trapezium approach the radius.

As the carpus move back to full ulnar deviation, the proximal row extends to equal amount. The scaphoid can be observed to extend with ulnar deviation but it is the proximal migration of the hamate that forces the triquetrum to displace volarly and extend, bringing the lunate with it.

Normally, in the coronal plane, the center of rotation of the wrist is located within a small area in the capitate neck. A line through the axis of rotation parallel with the anatomic axis of the forearm will, with the hand in a neutral position, pass through the head and base of the third metacarpal, the capitate, the radial aspect of the lunate, and the center of the lunate fossa of the radius. In the sagittal plane with the wrist in neutral flexion extension, a line passing through the longitudinal axis of the capitate, lunate and radius will show these to be nearly super imposed or collinear. The scaphoid axis lies 45 degrees to the above and passes between lunate and capitate in a fashion that provides optimal stability to the midcarpal joint. The scaphoid acts as a stabilizing strut of column to support the inherently unstable central column. The interosseous membrane is taught in neutral rotation and somewhat relaxed in complete pronation or supination. The triangular fibrocartilage, not only resists the diastases at inferior radio-ulnar joint but limits the pronation and supination by its torque mechanisms of 'in-phase' tautening.

Pronator quadratus is the principal pronator, aided by pronator teres only during forceful and rapid pronation. Flexor carpi radialis owing to its oblique, course also is a weak pronator. Supinator acts in slow, un resisted movement especially in the extended elbow.

Fast and forceful supination, with elbow flexion is done by biceps brachii. Supination is a stronger movement than pronation.

PATHOMECHANICS OF DISTAL END RADIUS FRACTURE

The distal radius fracture is caused by a fall on the outstretched hand. When a person falls on to the outstretched hand, the prominent thenar eminence takes the brunt of force. The fractures of the lower end of radius occurs while the triangular fibrocartilage is still intact, therefore there is a rotary element with center of rotation at the ulnar styloid; the lower end of the radius rotating into supination. If the force continues, the ulnar styloid is avulsed. Therefore there can be a wide variety of displacements of lower end of radius, but basically six positions are recognized. These are impaction, lateral displacement, lateral rotation, dorsal displacement, dorsal rotation and supination. The brachioradialis is the only muscle inserted to the distal radius and acts as a deforming force.

Fig - 6 Mechanism of the injury

When a person falls on an out stretched hand, there is transmission of 80% axial load to distal radius and 20% axial load to distal ulna / TFCC. 90% of wrist injuries are caused by stress loading with wrist in dorsiflexion(fall onto outstretched).Wrist in $40^0 – 90^0$ dorsiflexion produces distal radius fracture. Wrist in >

90^0 dorsiflexion produces carpal injury. The palmar tensile force fails first then the dorsal compression force produces comminution of dorsal cortex. (Comminution of distal radial metaphysis is defined as involvement of >50% of the diameter of metaphysis as seen on any radiograph, comminution of at least two cortices of metaphysis, or >2mm of shortening of the radius)[10] .

Majority of the distal radial fractures are extra-articular, 60% associated with ulnar styloid fracture, 50% associated with TFCC tears, 12% associated with carpal fractures.

Distal radius fractures that have a shear or compression component produce intra-articular fractures that are considerably more unstable than bending metaphyseal extra-articular fractures. Concomitant ligamentous injuries are therefore to be expected. In elderly extra-articular metaphyseal fractures and in younger comminuted, intra-articular fractures are common. The amount of force necessary to produce distal radius fracture varies in dorsiflexed wrist from 105-440 kg with mean of 195 kg for women and 282 kg for men.

Fractures of the distal radius are produced when the dorsiflexion of the wrist varies from 40 to 90 with lesser amounts of force being required at smaller angles. Recently a study has evaluated that the patient need only fall from a height of 0.6m to generate enough force to fracture an average distal radius assuming no absorption of load by adjacent joints- hand, elbow or the ipsilateral shoulder[11].

IMAGING TECHNIQUES[12]

A radiographic survey of the distal radius and ulna can be accomplished with simple posteroanterior (PA) and lateral views; however, a four-view series is recommended for a more complete evaluation of the wrist. This includes PA and lateral views, an external oblique projection, and a PA view with the wrist in ulnar deviation. An external oblique view is obtained with the radial side of the wrist elevated at a 30° angle off the table or film screen, with the ulnar side of the hand and wrist on the table. The external oblique view is the only one of these survey views that demonstrates the trapeziotrapezoiqal joint; it also demonstrates the waist of the scaphoid. Placement of the wrist in ulnar deviation while in the PA position elongates the scaphoid and helps improve detection of subtle scaphoid fractures. Standardized positioning and high-quality radiographs must be obtained for optimal evaluation at the time of injury and subsequent follow-up.

A standard PA view of the wrist should profile the extensor carpi ulnaris tendon groove, which should be at the level of or radial to the base of the ulnar styloid. A true lateral view is defined by a scaphopisocapitate relationship. On a standard lateral view, the palmar cortex of the pisiform bone should overlie the central third of the interval between the palmar cortices of the distal scaphoid pole and the capitate head. These two criteria provide an objective measure of true standard PA and lateral views

When evaluating radiographs in patients with a high potential for a fracture, the bone cortices must be carefully evaluated for evidence of discontinuity. One must evaluate both the PA and the lateral views because a subtle fracture may be apparent on only one view. On the PA view, cortices of the scaphoid, lunate, and sigmoid fossae of the distal radius should be carefully examined for cortical offset. On the lateral view, all cortical structures, including the distal radius, the ulna, "the carpal bones, and the metacarpal cortices, should be examined carefully for cortical break. Soft-tissue swelling must also be carefully assessed. With focal swelling, close observation of underlying cortices may show a fracture or subluxation. The distal ulna should also be closely evaluated when a distal radioulnar subluxation or dislocation is considered.

With fracture comminution, displacement, or complex intra articular extension, radiography may be insufficient and computed tomography (CT) is warranted. CT should be performed if conventional radiographs provide insufficient detail and, specifically, when a detailed evaluation is needed of radiocarpal articular step-off and gap displacement-factors crucial in predicting the development of radiocarpal osteoarthritis.

CT of the distal radius, ulna, and carpus can be performed in several planes. CT in the transverse plane is often used to evaluate the distal radioulnar joint and the carpal bones or to further assess a longitudinal fracture. The coronal plane provides an image similar to the standard PA radiograph but will provide better soft-tissue and bone detail than will a routine radiograph. Coronal CT also demonstrates the radiocarpal joint well. The oblique sagittal plane in the long axis of the scaphoid was developed to better assess the scaphoid. The wrist is pronated and the scans are obtained along a line between the base of the thumb and the Lister tubercle (dorsal tubercle of radius). In subtle cases of distal radioulnar subluxation, a comparison of transverse CT images of both wrists in the neutral, prone, and supine positions or in any position that reproduces the patient's pain may be helpful. In general, 2-mm-thick sections at 2-mm intervals will be satisfactory to show the anatomic detail of distal radius and ulnar fractures along articular surfaces.

Magnetic resonance (MR) imaging is of benefit when concomitant ligamentous injuries are suspected or if fracture is suspected but not demonstrated on routine radiographs. MR imaging should provide images in at least the transverse and coronal planes, and at least one sequence sensitive for fluid with fat suppression should be included. Section thickness should preferably be 3 mm or less for evaluation of bone marrow. Thinner sections are necessary for ligament evaluation. Arthrography is valuable when looking for scapholunate, lunotriquetral, TFC, or TFCC defects.

Standard radiographic assessment to quantify deformities associated with distal radius fractures should also consist of three radiographic measurements, which correlate with patient outcome. **Radial length** (radial height) is measured on the PA radiograph as the distance between one line perpendicular to the long axis of the radius passing through the distal tip of the sigmoid notch at the distal ulnar articular surface of the radius and a second line at the distal tip of the radial styloid. This measurement averages 10-13 mm.

Radial inclination, or radial angle, is also measured on the PA radiograph and represents the angle between one line connecting the radial styloid tip and the ulnar aspect of. The distal radius and a second line perpendicular to the longitudinal axis of the radius. The radial inclination ranges between 21° and 25°. The **volar tilt** of the distal radius is measured on a correctly positioned lateral radiograph. The volar tilt represents the angle between a line along the distal radial articular surface and the line perpendicular to the longitudinal axis of the radius at the joint margin. The normal volar tilt averages **11**° and has a range of 2°-20°.

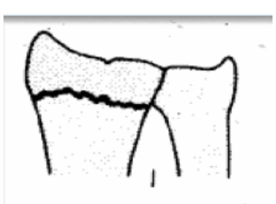
CLASSIFICATION

Classification of distal radial fractures has largely occurred in the past two hundred years. Fracture eponyms pay tribute to those who initiated the process: Pouteau, Colles, Barton, Goyrand, and Smith. Each described one or more specific fractures that they characterized by clinical evaluation or laboratory dissection, without the aid of X-rays. With this foundation, many investigators progressively contributed to the breadth and depth of understanding of distal radial fractures based on fracture attributes and severity each method of classification had its champions, who touted its strengths, but always there were critics which identified weaknesses as well.

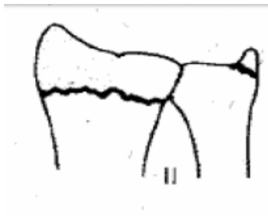
Gartland and Werley Classification (modified by Sarmiento24 1975)[13]

Type I A	Extra-articular
Type I B	Extra-articular, displaced
Type II	Intra-articular, non displaced
Type III	Intra-articular, displaced

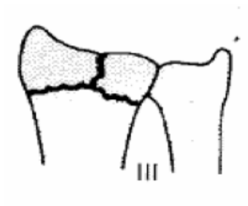
Classification of Frykman[14]



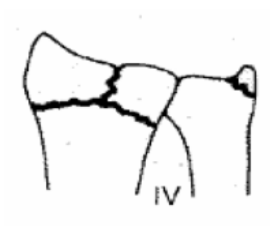
Type – I - Extraarticular



TYPE -II - Extraarticular with fracture of the distal ulna

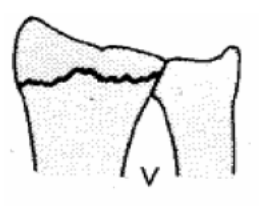


TYPE -III - Intraarticular involving the radiocarpal joint

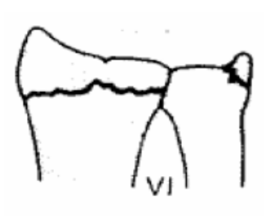


TYPE -IV - Intraarticular involving the radiocarpal joint

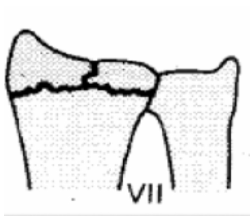
with fracture of the distal ulna



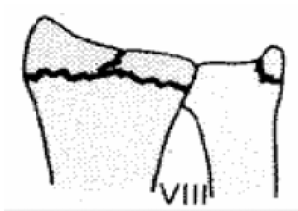
TYPE -V - Intraarticular involving the distal radioulnar joint



TYPE -VI - Intraarticular involving the distal radioulnar joint with fracture of the distal ulna



TYPE -VII - Intraarticular involving both radiocarpal and distal radioulnar joints



TYPE -VIII - Intraarticular involving both radiocarpal and distal radioulnar joints with fracture of the distal ulna

Classification of FERNANDEZ[15,16]

Type 1 *Bending*: One cortex of the metaphysis fails due to tensile stress; opposite cortex with some comminution

Type 2 *Shearing:* Fracture of the joint surface

Type 3 *Compression:* Fracture of the joint surface with impaction of subchondral and metaphyseal bone, intraarticular comminution

Type 4 *Avulsion:* Fracture of the ligament attachments of the ulnar and radial styloid process, radiocarpal fracture-dislocation

Type 5 *Combination:* High-velocity injuries

Classification of modified AO

Type A Extraarticular

Type B Partial articular

B1–radial styloid fracture

B2–dorsal rim fracture

B3–volar rim fracture

B4–die-punch fracture

Type C Complete articular

Classification of Melone[17]

Type 1 Minimal comminution, stable,

Type 2 Comminuted - Stable, displacement of medial complex:

Type 3 Displacement of medial complex as a unit + anterior spike,

Type 4 Wide separation or rotation of the dorsal fragment and palmar fragment rotation

Classification of Lidstorm[18]

Type 1 – Non displaced

Type 2 - A. Extra-articular fracture with dorsal angulation

B. Intra-articular fracture with dorsal angulation

C. Extra-articular fracture with severe displacement

D. Intra-articular fracture with severe displacement

F. Intra-articular comminution with severe displacement

CLASSIFICATION OF OLDER[19]

TYPE 1 – Non displaced, up to 50 dorsal angulation, radial articular surface < 2 mm above ulnar head.

TYPE 2 – Displaced with minimum comminution dorsal angular or displacement, radial articular surface <3mm below ulnar head minimal comminution of the dorsal radius.

TYPE 3 – Displaced with comminution of dorsal radius – radial articular surface below ulnar head, minimal comminution of distal fragment.

TYPE 4 – Displaced with severe comminution of radius – marked comminution of dorsal and distal radius articular surface 2-8mm below ulnar head

TREATMENT ALTERNATIVES

Although anatomic reduction remains the goal, surgical techniques are evolving in an attempt to minimize postoperative stiffness, decrease surgical risk, and reduce the quantity of internal and external fixation hardware. Several treatment alternatives to closed reduction and casting are available, these include pins and plaster technique, closed reduction and percutaneous pinning, intrafocal pinning (Kapandji's method), closed reduction and external fixation, limited open reduction, and open reduction and internal fixation with or without bone grafting. Augmentation of the external fixation using percutaneous Kirschner (K) wires and arthroscopically assisted reduction of intraarticular fractures have been shown to be useful.

Conservative

Closed reduction and cast immobilization is still the mainstay of treatment for nondisplaced stable fractures. This fracture type is characterized by minimal radial metaphyseal comminution, minimal or no loss of height, and no substantial displacement or angulation. A well-padded splint with the wrist in neutral position, the metacarpophalangeal joints completely unobstructed, and the overlying wrap loosely approximated provides adequate immobilization of a truly stable and nondisplaced fracture, without contributing to hand swelling and stiffness. In an attempt to prevent displacement of the reduced fracture during immobilization in a splint or plaster cast, placement of the wrist in the position of acute flexion, extreme pronation, and ulnar deviation (the Cotton-Loader position) has been used in the past.

The pins-and-plaster technique of external fixation was first introduced by Bohler in 1929. Pins are placed at sites that are distal and proximal to the fracture and are then held in place externally with a plaster overwrap. Although appealing in concept, it is often difficult in practice. Application of the plaster around the pins may prolong the procedure sufficiently to prevent adequate molding of the cast. Subsequent dorsal redisplacement and angulation of the distal fragment has been one reason that the pins-and-plaster technique is now infrequently used.

Operative Treatment

Surgical management is recommended for difficult fractures because it offers the potential to minimize residual deformity and loss of function.[20]

In addition, surgical management is a more reliable method of reduction for significantly displaced intraarticular fractures and, thus, should decrease the risk of posttraumatic arthritis.

Closed Reduction and Intrafocal Pinning (Kapandji'sTechnique)

Intrafocal pinning originally was described in 1976 by Kapandji and has been used widely in Europe. Essentially a variation of percutaneous pinning, the technique consists of limited open placement of buttressing K wires. The original indication was an unstable extraarticular fracture in a young adult; however, the indications have been extended to include elderly patients and intraarticular fractures with minimal displacement.

Contraindications are significant intraarticular involvement, volar comminution, advanced osteopenia, and the inability to achieve a satisfactory reduction by closed manipulation before pinning.

The current technique uses three 0.062-inch K wires inserted through small incisions directly over the fracture between the first and second, the third and fourth, and the fourth and fifth dorsal wrist compartments.

Pins initially are inserted directly into and parallel to the fracture and then are directed 45degree obliquely and proximally to engage the opposite cortex. This maneuver reduces the fracture additionally and provides a buttress for the distal fragment. Although no cast immobilization was used in the original description, a cast now is used commonly for 6 weeks. Several series from Europe have shown good results using this method. A recent report from the United States using Kapandji's technique in 23 patients claimed good and excellent radiographic results in 79% of patients younger than 65 years of age and 100% of those older than 65 years of age. The technique seems to offer many advantages for simple to moderately difficult fractures that cannot be managed by cast treatment alone.

Closed Reduction and External Fixation

External fixation devices are an excellent means of overcoming the displacing forces of the forearm muscles that can pull comminuted distal radial fractures into a collapsed, shortened position. With severe comminution of the metaphysis, the reconstructed articular surface cannot be stabilized to the shaft of the radius. An external fixator can provide the stability when both volar and dorsal cortices are comminuted.[21,22] External fixation is a valuable instrument for fracture reduction and stabilization. Limited open incisions, early range of motion, and treatment of complex wounds are few of the benefits of external fixation.[23]

There has been a constant evolution in technique and device design since the original idea of maintaining skeletal traction 'with an external frame was described, in 1944, by **Anderson and O'Neil.** Much has been learned and improved upon since then. The initial practices of excessive distraction, positioning of the wrist in extreme flexion and ulnar deviation, and long period of wrist immobilization (over eight weeks) created frequent problems with postoperative pain, wrist and hand stiffness, disuse atrophy nonunion and reflex. Sympathetic dystrophy. Experience and an understanding of the involved physiologic and biomechanical principles allowed these complications to be minimized. The realization that ligamentotaxis does not always accomplish anatomic reduction of all intra-articular and extra-articular fracture components spurred the development of new techniques and improvements in devices. In the case of unstable fracture fragments, the addition of percutaneous pinning or internal fixation techniques allowed for external fixation with only moderate distraction to prevent metaphyseal shortening and to neutralize the extensor and flexor forces across the fracture site. The need for positioning the wrist in extreme flexion and ulnar deviation to provide reduction also was diminished or eliminated. The wrist may initially be over distracted to aid in reduction, but it must subsequently be decreased to an acceptable amount following fixation.

A large variety of devices are available for external fixation of fractures of the distal aspect of the radius. All involve distraction across the wrist joint with placement of pins in the radius and the metacarpals. Newer external fixation devices are lighter, easier to assemble and implant, adjustable once the device is secured, and they are radiolucent.

External Fixation with Distraction and Bone Grafting

Shows excellent results. The indications included fractures with comminution, displacement, and intraarticular involvement. Distraction with external fixation is used to achieve and maintain extraarticular reduction by ligamentotaxis. A dorsal incision is made over the fracture site, and iliac crest graft pushed into the fracture. The contour of the carpal surface serves as a mold to realign the articular surface

Arthroscopic Assisted Reduction

Percutaneous and limited open reduction techniques combined with wrist arthroscopy in the management of displaced distal radial fractures has been described recently by Geissler and Freeland. They showed that wrist arthroscopy provides an excellent view for restoration of the articular surface with minimal soft tissue dissection. Twenty-five of 33 patients with various fracture patterns had an anatomic articular reduction. Wrist arthroscopy also allowed for- detection of a wide spectrum of carpal interosseous ligament tears and osteochondral loose bodies.

Open Reduction and Internal Fixation

Open reduction and internal fixation using a wider exposure is indicated for comminuted intraarticular fractures and shear fractures, such as volar Barton's fractures. These types of fractures cannot be reduced by ligamentotaxis and are more unstable after reduction.

Bone - grafting, various types of hardware, and external fixation should be considered.

The main objectives are to reduce the articular surface and to neutralize the forces that cause displacement during fracture healing. However, indiscriminate use of hardware will increase the risk of complications.

New Alternatives

Various new techniques have been described recently for the treatment of distal radial fractures.

Micronail1[24]

With the advent of this new device, a decrease in soft tissue complication is expected.

The implant utilizes the principles of load sharing, subchondral screw divergence, and locked fixed-angle fixation. It is inserted through a small skin incision at the radial styloid and does not further devascularize the fracture fragments. The limited surgical dissection and rigid fracture fixation allow for minimal postoperative immobilization and an early return of function

Combined Internal and External Fixation

Blair et al reported on combined internal and external fixation for the treatment of 10 AO-C3 fractures of the distal radius with an average follow up of 5 years. They showed that this surgical strategy can produce predictably satisfactory results in a specific subset of complex and very difficult to treat intraarticular distal radial fractures

In Situ Screw Placement

Persoons and Wagner reported on an original method allowing immediate fracture stability using a specially designed peg screw. The screw has a conical design to reduce the bone gap in the posterior cortex, and a polished head to avoid tearing the extensor tendon. The peg screw must be introduced in the fracture site dorsally toward the anterior cortical fracture. In a series of 50 patients treated consecutively Persoons and Wagner obtained a high rate of satisfactory results.

Closed Reduction and Percutaneous Injection of a Paste That Forms a Carbonated Apatite

Jupiter et al recently published a longitudinal study that evaluated the role of Norian SRS- TM injectable paste in treating unstable older Types III and IV distal radial fractures. Five patients were treated by this method followed by fiberglass cast immobilization. Clinical and radiographic data showed maintenance of nearly anatomic reduction. No adverse effects were identified.

Low Intensity Pulsed Ultrasound

Kristiansen et al recently reported on the effect of pulsed low intensity ultrasound on controlling the loss of reduction in a subset of 61 distal radius fractures consecutively randomized into two treatment groups. Thirty distal radial fractures were treated with the ultrasound device, which provided low intensity pulsed ultrasound to the fracture site for one 20-minute therapy session each day. Thirty-one fractures were treated with a placebo device. The results seem to indicate that in distal radial fractures, low intensity ultrasound therapy can accelerate radiographic healing and minimize the loss of reduction which can lead to physical disability. The addition of pulsed electromagnetic field to ice therapy produces better overall treatment outcomes than ice alone, or pulsed electromagnetic field alone in pain reduction and range of joint motion in ulnar deviation and flexion for a distal radius fracture after an immobilization period of 6 weeks.[25]

COMPLICATIONS

Perhaps no fracture is as ubiquitous and fraught with potential complications as the distal radius fractures. Cooney et al reported 31% overall complication rate, many due to incomplete restoration of radial length or secondary loss of reduction

1. Radiocarpal, radioulnar arthrosis

2. Median nerve injury

3. Malunion, nonunion (rare)

4. Tendon rupture (usually EPL, possibly ischemic etiology), Tendon adhesion, tenosynovitis

5. Digital stiffness

6. Decreased grip strength

7. RSD (increased pain, swelling, paraesthesia)

1. Post-traumatic arthritis:

There is a strong association between post-traumatic arthrosis and Residual displacement of articular fragments (> 2mm) at time of osseous union. Functional status does not always correlate with magnitude of articular step-off or displacement (Catalano 1997)[26] .Baratz et al (1996) in a cadeveric study reported that contact stress areas significantly increased with intra-articular step-offs > 2 mm. Subsequent traumatic osteoarthritis can develop even in patients with excellent reduction.

2. Malunion:

Union with deformity is the most common complication following a distal radial fracture, the dorsal deformity of the distal articular surface increases load on distal part of ulna, produces radio-carpal instability, mid carpal problems, fixed carpal malalignment-that is, a dorsal intercalary segment instability, alteration in the extensor tendon function, increase in intra-compartmental pressure of carpal tunnel.

Loss of normal inclination in the frontal plane may position the carpal tunnel in a radial direction, angulating the flexor tendons and decreasing their mechanical advantage contributing to diminished strength. Distal radioulnar joint may be impaired as producing incongruity of the sigmoid notch articulation with the ulnar head. Radial shortening can lead to tightening of the TFCC and impedance in the arc of forearm rotation as well as impaction of ulna head onto carpus (Ulno-carpal abutment syndrome). The three conditions responsible for wrist pain associated with limited forearm rotation are incongruity, impaction, and instability of the distal radioulnar joint. Other, less frequent causes of wrist pain are painful nonunion of ulnar styloid fracture, palmar capsular contracture of joint. Function as reflected by grip strength and endurance was impaired when fracture healed with a dorsal angulation of $>20^0$, loss of radial tilt of $>10^0$ and radial shift of distal fragment >2mm.

Altered biomechanics in malunion,

1. Increased localized pressure / contact areas - post-traumatic arthrosis
2. Radial shortening is parameter which most adversely affects DRUJ kinematics
3. Progressive transfer of load to distal ulna Decision to treat malunion based on clinical symptoms and function loss and not on radiographic findings.

3. Neuropathy:

Median nerve injury is one of the most commonly observed complication. The incidence of neuropathy has been reported to be as high as 22% in distal radius fractures.

It may occur as acute in 13% due to contusion, stretch, edema, hemorrhage, volar fragment nerve impingement. Treatment is prompt fracture reduction and observation. Chronic median nerve neuropathy may occur in 23% due to persistent volar fragment, callous, malunion with increased risk of RSD. Immobilization of wrist in palmar flexion contributes significantly to the development of medial neuropathy.

The risk for acute carpal tunnel syndrome, when immobilizing the fractured wrist in 20^0 of flexion is 13% & in 40^0 of flexion is 43%. Carpal tunnel pressures are useful for distinguishing median nerve contusion from acute carpal tunnel syndrome. Median nerve contusion can be observed, where as acute carpal tunnel syndrome requires early decompression. Malunion can be responsible for late carpal tunnel syndrome where bone occupies space in carpal tunnel. Strong consideration should be given to corrective osteotomy in this particularly if he or she is young, rather than to carpal tunnel release. Osteotomy alone can cure the carpal tunnel syndrome. Compression of the ulnar nerve occurs at half the incidence of median nerve compression in distal radius fracture. It is more frequently seen in malunions, particularly with recurrent subluxations of ulnar head. Radial sensory damage is usually the result of complication with external fixation. This can be almost avoided with the incision and exposure before pin placement instead of percutaneous techniques.

4. Associated injuries

1. Ulnar styloid fractures: Ulnar styloid fractures are perhaps the most controversial of the associated bone injuries with regard to treatment. It is associated with 50-70% distal radius fractures

2. DRUJ injury: present to some degree in all displaced fractures. It is the most common cause of residual disability. The key to successful outcome is exact anatomic restoration of joint. If DURJ is palpably unstable, stabilization is required.
3. long-arm cast or an ulnar outrigger is used to prevent pronation and supination for 4weeks, TFCC repair or resection may be done in selected cases
4. Scaphoid Fractures: accounts for < 1%. Screw fixation seems advisable.
5. Tears of the Scapholunate and other inter carpal ligaments have be endocumented to occur in up to 70%. TFCC is frequently injured in conjunction. Fractures of the radial styloid are frequently associated with Scapholunate injuries.
6. Scapholunate Dissociation: Uncommon in distal radius fractures. Scapholunate interosseous ligament and radio scapholunate ligament may be involved. Distraction may increase the displacement of the scapholunate joint. Static fixation in a strictly neutral position with an ulnar outrigger supplement for 6 weeks is needed. In younger patients acute repair of the ligament may be attempted.

COMPLICATIONS OF EXTERNAL FIXATION

1. Pin tract Infection: The best defense against pin tract infection is proper pin insertion technique, meticulous postoperative care, using hand drill instead of power drill to avoid thermal necrosis and daily pin site care with methylated spirit to reduce colonization of bacteria.
2. Pin loosening and breakage.
3. Iatrogenic fractures.
4. Loss of reduction.

Other Complications:

1. Reflex Sympathetic Dystrophy (RSD): occurs in 0.1% -26%. Early recognition and aggressive treatment including active physiotherapy and sympathetic block resolves this complication.

2. Other complications occurring less frequently include nonunion, rupture of extensor pollicis longus tendon, rupture of flexor pollicis longus, and osteoarthritis.

3. Complications of over distraction: Over distraction results in stiffness, decreased grip strength, delayed union. Fixator induced increase in skeletal length; produce wrist flexed position and claw hand. Although initial over distraction is useful for fracture dis impaction and alignment, maintenance of excessive distraction is clearly detrimental.[27,28] Optimal distraction is suggested by full range of passive metacarpophalangeal and Interphalangeal flexion, radiocarpal & midcarpal joint space in X-ray (<2mm)

REVIEW OF LITERATURE

In 1979, Cooney WP 3rd, Linscheid RL, Dobyns JH[29] used External pin fixation for unstable Colles' fractures. During a five-year period, a double-pin Roger Anderson apparatus, with pins perpendicularly placed in the second and third metacarpals and in the distal part of the radius, was applied in 130 patients with an unstable Colles fracture.

Sixty of the 130 were followed for two years. Patient assessment revealed that 85 per cent of the patients had good results; 12 per cent, fair; and 3 per cent, unsatisfactory. Sixteen patients had complications; seven of the sixteen had pin loosening, which occurred most frequently late during the course of treatment and without adverse sequelae.

In 1983, Jonsson U[30] used External fixation for re dislocated Colles' fractures. Rereduction was carried out in 5% of all treated Colles' fractures and they were externally fixated with a one-bar Hoffmann apparatus. The results of 57 of the first 69 patients treated with a follow-up time of at least 1 year are presented. Using Frykman's criteria, 18 patients were judged as "excellent", 25 as "good" and 14 patients were judged as "unsatisfactory". Among the first patients, five cases of pin loosening were seen, but there were no adverse effects in the final result. There were no pin-tract infections. The results justify using the method as a routine when a re dislocated Colles' fracture is re reduced.

In 1985, Vaughan PA, Lui SM, Harrington lJ, Maistrelli GL[31]. Used The Roger Anderson external fixator in the treatment of unstable fractures of the distal radius in 52 patients, and the results evaluated after a follow-up averaging 58 months.46 patients (89%) had good or excellent results and six (11 %) were classified as fair. There were no poor results. Seven patients (14%) developed complications.

None of these affected the long-term results except in one elderly woman where the pins loosened and had to be removed.

In 1986, Altissimi M, Antenucci R, Fiacca C, Mancini GB[32] studied the long term results of conservative treatment of fractures of the distal radius. The long-term results of the conservative treatment of wrist fractures were observed in a follow-up study of 297 cases over a period of one and one-half years to six years. The results were: excellent in 38% of cases, good in 49%, fair in 11.5%, and poor in 1.5%. They concluded that, fractures of the distal radius are not to be underestimated and long term results following conservative treatment may not be as acceptable as is generally assumed.

In 1986, Knirk JL, Jupiter JB[33] studied Intra-articular fractures of the distal end of the radius in young adults. A retrospective study of forty-three fractures in forty young adults (mean age, 27.6 years) was done to determine the components that are critical to the outcome. Treatment included application of a cast alone in twenty one fractures, insertion of pins and application of a plaster cast in seventeen, external fixation in two fractures, and open reduction and internal fixation in three fractures. At a mean follow-up of 6.7 years, 26 per cent were rated as excellent; 35 per cent, as good; 33 per cent, as fair; and 6 per cent, as poor. There was radiographic evidence of post-traumatic arthritis in twenty-eight (65 per cent) of the fractures. Accurate articular restoration was the most critical factor in achieving a successful result. Nonunion of the ulnar styloid process adversely affected the results.

Clyburn[34] in 1987 treated 31 comminuted intra-articular fracture of the end of Radius with dynamic external fixation and reported that the wrists allowed full flexion and extension immediately postoperatively had lost some volar tilt post operatively. And in patients where 28 only flexion was allowed immediately postoperatively and extension after four weeks did not lose volar tilt.

In 1989, Leung KS, Shen WY, Leung PC, et al[35] performed ligamentotaxis and bone grafting for comminuted fractures of the distal radius. They stated that, the conventional treatment of comminuted fractures in the distal radius has been unsatisfactory. Therefore a prospective study using the principle of ligamentotoxis and primary cancellous bone grafting as the uniform method of treatment was used. Ligamentotaxis was maintained by using an external fixator for three weeks only, after which a carefully monitored programme of rehabilitation was given. We have reviewed 72 consecutive distal radial fractures after a follow-up of7 to 40 months (average 11 months). Reduction had been maintained during healing and over 80% of patients regained full range of movement in hands, wrists and forearms with strong and pain-free wrist function. Complications were infrequent and gave no real problems. They conclude that distraction, external fixation and bone grafting appears to be an excellent method of treating comminuted fractures of the distal radius.

In 1989, Howard PW, Stewart HD, Hind RE, Burke FD[36] reported a prospective, randomised, controlled trial of 50 severely displaced comminuted Colles' fractures treated by either external fixation or manipulation and plaster. Each patient was assessed radiographically throughout treatment, and functionally by an independent observer at three and six months. The functional result correlated with the anatomical result, which was significantly better in patients treated by external fixation. This resulted in significantly improved function especially in young patients, and also a lower complication rate. They recommend the use of external fixation for young patients with comminuted displaced Colles' fractures unless manipulation and plaster show excellent reduction.

In 1989, Kaukonen Jp, Karaharju E, Luthje P, Porras M[37]used External fixation for Colles' fracture. Radiographic and functional results of external fixation of 32 Colles' fractures were compared with the results of plaster fixation of 189 Colles' fractures.

Despite the fact that the fractures treated with the external device were more unstable and comminuted, the final results were equal in both groups, and the radiographic outcome of external fixation was superior. Pin loosening decreased with predrilling rather than self-tapping. They recommend external fixation for unstable fractures of the distal forearm.

Abbaszadegan et al[38] (1989) reported that initial radial axial shortening > 5mm was greatest prognostic factor for redisplacement of fracture and unfavorable anatomic end result. Howard and coworkers (1989) found that functional results in distal end Radial fractures were related more to the quality of the anatomic restoration than to the method of immobilization

In 1990, Bartosh RA, Saldana MJ[39]conducted a cadaveric study to determine if ligamentotaxis restores radiopalmar tilt in Intraarticular fractures of the distal radius. They concluded that, ligamentotaxis alone is not a reliable method to reestablish radiopalmar tilt in intraarticular distal radius fractures.

Stein-H et[40] (1990) reported that comminuted intra-articular fractures of the Distal radius should be treated with external fixation, which maintains accurate Anatomic position until solid fracture healing is achieved. Precise small fragment reduction and restoration of articular congruity must be achieved by limited internal fixation using K-wires and occurrence of late collapse is prevented by subarticular bone grafting of the metaphyseal defect.

Seitz-WH Jr et al[41] (1990) through a series of biomechanical analyses showed that pin related complications can be minimized by using 4mm pins after central predrilling with limitedopen surgery, with proximal placement in the radius and distal placement through six cortices of the bases of the second and third metacarpals.

In 1991, Sanders RA, Keppel FL, Waldrop JI[42] said that external fixation of unstable fractures of the distal radius yields satisfactory results but has a high complication rate.

They studied thirty-five fractures in thirty-four patients to determine whether the results obtained with external fixation warranted it use. The frequency of complications and the limitations of external fixation demand caution on the part of the surgeon to prevent iatrogenic morbidity, which would limit the benefits of the technique.

Jakim I et al[43] (1991) in a prospective study of 132 patients with an average age of 35years, unstable intra-articular fractures of the distal radius were treated by external fixator. 83% of patients had good or excellent results. He concluded that there was a statistically significant correlation between the severity of the fracture and the clinical outcome, irrespective of radiological restoration. Articular and soft-tissue damage following violent compressive forces may lead to a degree of functional impairment.

McQueen MM et al[44] (1992) reported that although external fixation can achieve restoration of normal anatomy, functional outcome may be poor because of these verity of the associated soft tissue injury.

In 1993, Cooney WP[45] proposed a modem treatment-based classification for fractures of the distal radius. He stated that, specific treatment planning can result from reference to the classification

Sommer kamp*et al*[46] (1994) reported that motion of the wrist in the dynamic-fixator group resulted in a significant loss of radial length compared with that in the static fixator group, and the clinical result cannot support the concept of early mobilization with a dynamic external fixator.

In 1994, Trumble TE, Schmitt SR, Vedder NB[47] studied factors affecting functional outcome of displaced intra-articular distal radius fractures. They said that, degree of articular step-off, gap between fragments, and radial shortening are strongly correlated with improved outcome.

In 1994, Bishay M, Aguilera X, Grant J, Dunkerley DR[48] put-forth the results of external fixationof the radius in the treatment of comminuted intraarticular fractures of the distal end. 14 unstable comminuted intraarticular fractures of the distal radius were treated by the use of the *AlO* mini-external fixator. The distal pins were inserted in the distal fragment, thus leaving the wrist joint free to mobilize. Clinical results were assessed at 3 to 12 months using the Sarmiento demerit point system. Nine were male and five female, with a mean age of 37 years. Ten fractures were closed and four were open. 11 patients (78.5%) had an excellent functional score and three (21.5%) had a good score. All patients had normal wrist morphology with an average radial length of 11 mm, radial angle of 23 degrees and a mean volar angle of 12 degrees. 12 patients had anatomical radio-carpal and radio-ulnar joints and two patients had a step less than 2 mm at the radio-carpal surface. This method has proved to be reliable in maintaining the position as well as allowing early functional recovery.

McQueen MM et al[49] (1996) performed a prospective, randomized trial on 120 patients with redisplaced fractures of the distal radius comparing four methods of treatment. The radiological results showed improvement in angulation of the distal radius for the open reduction and bone grafting group. Functional results showed no difference between any of the four groups. The main influence on final outcome was carpal malalignment which had a statistically significant negative effect on function.

Cannegieter DM et al[50] (1997) through a prospective study of the treatment of 32 unstable Colles‘ fractures by external fixation and cancellous grafting with minimal exposure had 84% good to excellent results and concluded that the combination of cancellous grafting and external fixation is effective for the treatment of unstable colles' fracture

McQueen MM[51] (1998) in a randomized, prospective study carried out on 60 patients with unstable fractures of the distal radius reported that radius shortening is most consistently correlated with poor function and non-bridging external fixation is the treatment of choice for unstable fractures of the distal radius which have sufficient space for the placement of pins in the distal fragment.

Gunaki RB et al[52] (1998) reported that restoration of anatomy of lower end of radius and maintaining it throughout the period of healing is essential for better functional end result. A study of 30 patients with dorsally displaced intra-articular fractures treated by closed reduction and external fixation showed that results in about 66%were excellent & in 86.6% excellent to good functional results were observed.

In 1999, Davenport wC, Miller G, Wright TW[53] conducted a cadaveric study to evaluate Wrist ligament strain during external fixation. At 10 mm of Wrist Jackdistraction, the strain in both the volar radioscaphocapjtate and dorsal radiotriquetral ligaments increased to greater than 20%. This increased strain may contribute to wrist stiffness.

In 1999, Wolfe SW, Austin G, Lorenze M, et al[54] conducted a biomechanical comparison of different wrist external fixators with and without K-wire augmentation. The data more strongly supported the concept of K-wire augmentation for increasing stability of an unstable extra-articular distal radius fracture regardless of the type of external fixator that is used.

In 2000, Kapoor H, Agarwal A, Dhaon BK[55] conducted a comparative evaluation of results following closed reduction, external fixation and open reduction with internal fixation in Displaced intra-articular fractures of distal radius. In the final functional assessment (Sarmiento) the results were (1) plaster 43% good and excellent, 50% fair and 7% poor, (2) external fixator 80% good and excellent, 20% fair and poor results, (3) open reduction and internal fixation 63% good and excellent, 26% fair, 11 % poor. They recommend that displaced severely comminuted intraarticular fractures should be treated with an external fixator.

In 2000, Young BT, Rayan GM[56] showed the outcome following non operative treatment of displaced distal radius fractures in low-demand patients older than 60 years. Twenty-five sedentary, low-demand patients older than 60 years were retrospectively evaluated for function and radiographic results following non operative treatment of displaced distal radius fractures. The mean age was 72 years and the average follow-up period was 34 months. Functional outcome was satisfactory in most cases; a high level of personal satisfaction and return to previous activity level was observed, regardless of the radiographic result. Non operative treatment of distal radius fractures yields satisfactory outcome, especially in those with low functional demands. It also is indicated in poor operative candidates.

Kleina W et al (2000)[57] in a prospective study of 103 distal radius fractures with the Pennig wrist fixator, obtained 87% excellent to good results. They suggested that good functional outcome cannot always be achieved with the fixator alone; often additional procedures are required in order to obtain an anatomical joint reconstruction.

Kapoor H et al[58] (2000) prospectively studied 90 adults with acute displaced intra articular fractures (average age 39) and recommended that in young individuals with acute intra articular fractures open reduction and internal fixation is best for anatomical reduction but external fixation best if severe comminution is present.

Functionally there was no difference between the two groups. Concluded that operative treatment is preferred in such cases and simple casting had no role.

Szabo R[59](2000) in a study of severely comminuted distal radius fractures, demonstrated that anatomical reduction could be maintained by external fixation despite wrist in neutral or extended position. Dynamic external fixation though allow for early motion of the wrist, there is a significant loss of radial length compared to static fixator group.

Kaempffe FA et al[60] (2000) retrospectively studied 19 patients with distal Radius fractures treated with external fixation and supplemental Kirschner wire fixation and reported poor outcome with respect to scores for pain, function, radiographs, motion, grip, strength, and final result with increased amount of distraction and increased duration of immobilization.

Singh N et al[61] (2001) reported malunion with radial deviation or dorsal angulation of $<10^0$ does not cause any loss of function. RSD is probably the most common and the most underestimated complication of wrist functions.

Putnam MD et al[11] (2001) concluded rehabilitation may alter the outcome after the initiation of fracture treatment particularly in regard to adjacent joint swelling, pain and residual stiffness. On advance with reference to external fixation is the value of pins at the fracture site to specifically fix larger fragments that are not stabilized by external fixation alone. With most fixation devices available patient should not undertake grip strengthening until fracture consolidation is evident clinically or radiologically.

Mehta JA et al[62] (2002) patients with highly comminuted Frykman's type 7 and 8 fractures were studied and concluded that non-bridging fixator, by allowing early physical activity, led to satisfactory functional and structural results.

Simic PM et al[63] (2003) External fixation devices are an excellent means of overcoming the displacing forces of forearm muscles. In case of unstable Fracture fragment additional per-cutaneous K-wire augmentation or internal fixation provide sufficient stability. Palmar translation in addition to longitudinal distraction can often restore the palmar tilt as well as maintain radial height.

Yamamoto K et al[64] (2003) did not support the concept of early mobilization with a dynamic external fixator as the early motion group showed a significant loss of RL and UV compared with the non-early motion group. Thus, it is important to carefully determine the time of initiating early motion during external fixation depending on the reduction status in individual patients. Use of a mobile external fixator facilitates the early initiation of exercise of the wrist joint, it may prevent the occurrence of joint stiffness, as well as enhance repair of the cartilagenous surface.

Werber KD et al[65] (2003) compared the radiographic and clinical results after use of a standard four-pin external fixator with those after use of a five-pin fixator with the fifth pin stabilizing the distal radial articular fragment. Follow-up radiographs demonstrated significantly less loss of alignment and length with the five-pin external fixator and concluded that rigid attachment of the fifth pin to the fixator frame may improve retention of the fracture reduction during fracture healing and may prevent loss of radial length by settling of the fracture fragments.

Akmaz I et al[66] (2003) studied 25 patients (mean age 39 years) with unstable distal radius fractures treated by external fixation found good to excellent anatomical results in 96% whereas good to excellent results functional results in only 42% and suggested that high success rates in anatomic results do not closely reflect satisfactory functional results.

Catalano LW III et al[67] (2004) indicated operative treatment for fractures With radiocarpal or distal radioulnar joint step or gap deformities greater than 1-2 mm, gross distal radioulnar joint instability, or those with extensive metaphyseal comminution rendering them particularly unstable after closed reduction. In general, they tend to lean toward operative fixation in younger, more active patients.

Nagi ON et al[68] (2004) prospectively used external fixators in 35 patients (5 weeks in18 patients and 8 weeks in 17 patients) and compared the results at 6 months. They concluded that fixator be kept for 5 weeks as no additional advantage is gained after fixator use for longer periods. Frykman grade has no significance to long term functional outcome. Observed that functional scores had perfect correlation with post reduction anatomical scores in concordance with other studies. Wrist is to be immobilized in neutral or slight extension so the long extensors are relaxed and MP joint can be flexed preventing finger stiffness after removal.

Aggarwal A et al[69] (2004) in a randomized prospective study 50 cases of fresh closed intra-articular fractures of distal end radius used K wires for radius and for metacarpal, connected each other by means of Knurled rods and clamps. They recommended that for maintaining the reduction of these fractures, external fixation is a better method than cast, percutaneous pinning or internal fixation which is difficult in cases of comminuted fractures and concluded that non bridging frame are better than bridging ones in selected cases of intra articular fractures of distal end radius.

Arora J et al[70] (2004) in a comparative study of comminuted intra-articular fractures of distal radius concluded that the external fixator is a versatile tool that is well established in the treatment of these fractures and it maintains the reduced position significantly better as compared to cast immobilization. They stated that comminuted intra-articular fractures of distal radius are common injuries that will not do well, unless certain treatment criteria are met and the result will be painful, stiff, dysfunctional wrist.

Kreder HJ et al[71] (2005) in a 2 year follow up of 179 adult patients with displaced intra-articular fractures of the distal radius reported that who underwent indirect reduction and percutaneous fixation had a more rapid return of function and a better functional outcome than those who underwent open reduction and internal fixation, provided that the intra-articular step and gap deformity were minimized.

Azzopardi t et al[72] (2005) concluded that percutaneous pinning of unstable, extraarticular fractures of the distal radius provided only a marginal improvement in the radiological parameters compared with immobilization in a cast alone.

E. K. shin, J. B. Jupitter[73] (2007) Germaine GQ Xu Siew Pang Chan, Mark Edward Puhaindran, Winston YC Chew (2009) There is no significant difference in the outcome of intra-articular distal radius fractures treated with either external fixator or internal fixation.

David H. Wei, Noah M. Raizman, Clement J. Bottino, Charles M. Jobin, Robert J. Strauch and Melvin P[74]. (2009) Use of a locked volar plate predictably leads to better patient-reported outcomes (DASH scores) in the first three months after fixation. However, at six months and one year, the outcomes of all three techniques evaluated in this study were found to be excellent, with minimal differences among them in terms of strength, motion, and radiographic alignment.

MATERIAL AND METHODS

We studied 30 cases with unstable comminuted intra-articular distal end of radius fractures prospectively fulfilling the inclusion and exclusion criteria from Nov 2012 to April 2014 at R. L. J Hospital, Kolar.

Inclusion criteria

1. Adults aged over l8 years with unstable distal end radius fractures.
2. All Closed unstable distal end radius fractures.
3. Open unstable distal end radius fractures (GUSTILO ANDERSON type 1, 2, 3a, 3b)

Exclusion criteria

1. GUSTILO ANDERSON open type 3C fractures.
2. Pathological factures.
3. Medically unfit patients.

Assessment of fractures of distal end radius was done with reference to skin condition (closed / open fracture), peripheral circulation, neurologic examination especially median nerve, flexor & extensor tendon function, distal radioulnar joint stability, compartment syndrome and associated injuries.

Radiographs of injured wrist taken included:

1) Postero Anterior view.

2) Lateral view.

Radiographic parameters noted were:

a) Radial inclination in PA view

b) Radial length in PA view

c) Palmar tilt in lateral view

d) Articular step off / displacement

Basic investigations like Haemoglobin%, blood grouping and typing, Random blood sugar, urine analysis, were performed.

In the preoperative period splintage with POP slab and elevation was Carried out which facilitate fracture reduction and precision of pins while applying external fixator.

SURGICAL TECHNIQUE

ANAESTHESIA:

General Anaesthesia was given in 8 cases and Brachial block in 22 cases.

The static external fixator used in this series consisted of

1. 3.5mm schanz screws/ K wires for the radius – 2 or 3 in number.
2. 2.5 mm schanz screws/ k wires for the second metacarpal.
3. clamps.
4. 4mm connecting rods.

SURGICAL TECHNIQUE:

Under the effect of anesthesia the patient was placed supine on the operation table. No Tourniquet was used. Intravenous antibiotics in the form of 1 gm of ceftriaxone was given 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. Under C arm control closed reduction of the fracture was carried out. Two stab incisions, one at the lateral aspect of the base of the 2^{nd} metacarpal and another, one inch distal to the former. Through each incision, similarly it was drilled with 1.5mm drill bit, and then fixed with 2.5mm schanz screws. Another two stab incisions were made, the first approximately 8cms 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),drill sleeve fixed centrally, through the drill sleeve radius was drilled with 2.5mm drill bit and with T-handle 3.5mm schanz screws were fixed through each incision and penetrating both cortex of the radius. The connecting rod was then connected to all the 4 schanz pin by means of clamps. Now the external fixation device is tightened and the reduction carefully assessed clinically and under fluoroscopy. For some cases augmentation of external fixation is done with k-wires to provide additional support to individual fracture fragments and increase stability. 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 for the next 5 days.

Post-Operative care and Rehabilitation:

Check X -rays were taken in both Antero-posterior and lateral views on postoperative day one. The reduction of the fracture was confirmed and any displacement of fracture was studied. Active exercises of fingers and thumb were commenced from the day of operation. Third postoperative day the dressing were removed. The patient was educated regarding pin site care. The patient was thought exercises for the hand, pronation and supination of the forearm and active movement of the elbow and shoulder were advised throughout the period of the healing.

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 between 6-8 weeks 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 and Physiotherapy was carried out regularly for 2 weeks. All the cases were followed at an interval of 6 weeks, 3 months & 6 months.

Fig 7: OPERATIVE PHOTOGRAPHS

IMPLANTS

STAB INCISION

SCHANZ PIN APPLICATION

EXTERNAL FIXATION

OBSERVATIONS

AGE DISTRIBUTION:

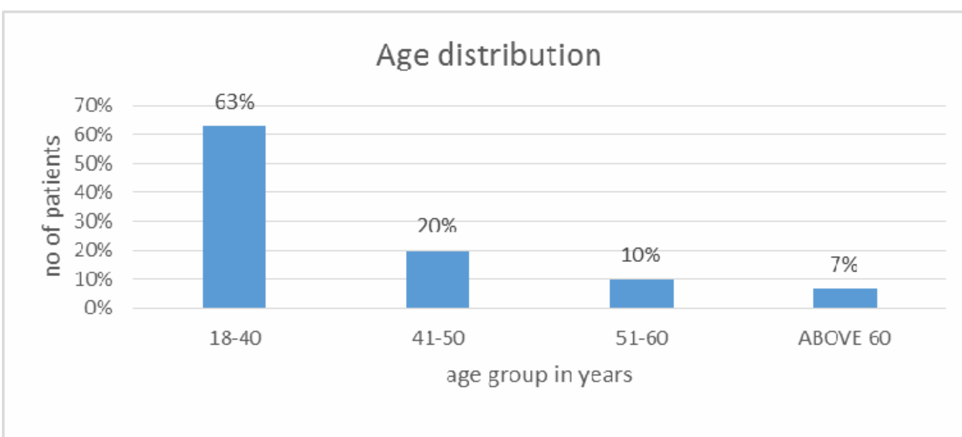
Table – 1

Distribution of patients according to age

AGE GROUP (yrs)	NO OF CASES	PERCENTAGE
18 – 40	19	63%
41 – 50	6	20%
51 – 60	2	10%
ABOVE 60	3	7%
TOTAL	30	100%

Majority of our patients were in the age group of 21-40 years. Youngest person was 18yrs old and oldest was 74yrs. Mean age was 38.06

Graph 1



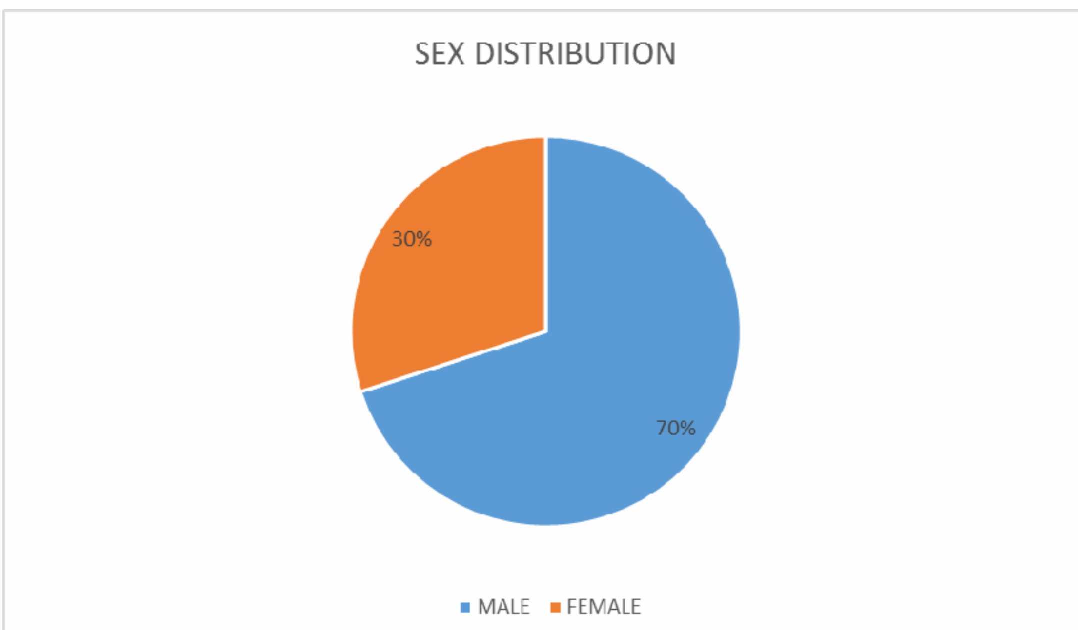
SEX DISTRIBUTION:

Table - 2

SEX	NO OF CASES	PERCENTAGE
MALE	21	70%
FEMALE	9	30%
TOTAL	30	100%

Out of 30 patients, 21(70%) were males and 9 (30%) were females.

Graph 2



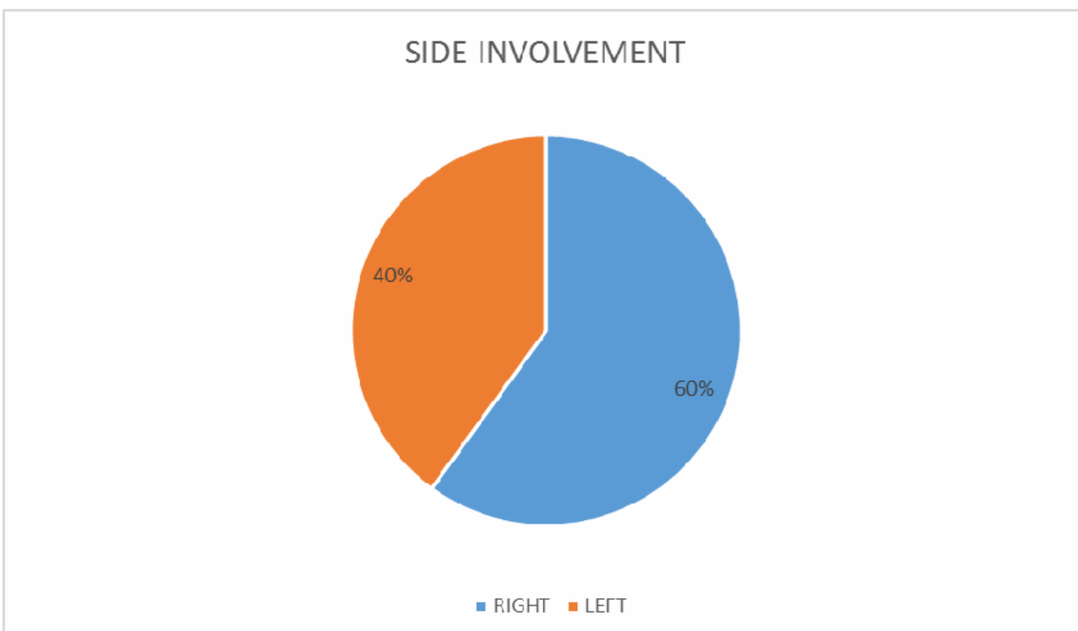
<u>SIDE OF INVOLVEMENT</u>:

Table – 3

SIDE	NO OF CASES	PERCENTAGE
RIGHT	18	60%
LEFT	12	40%
TOTAL	30	100%

In 60% of our cases dominant hand was found to be involved.

Graph 3



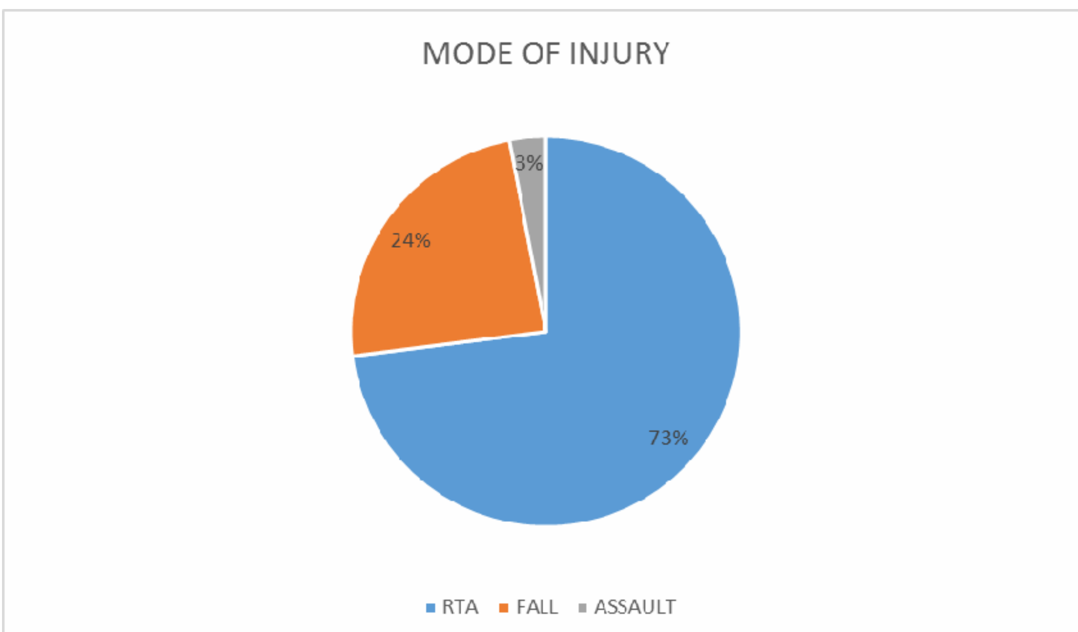
<u>MODE OF INJURY</u>:

Table – 4

MODE	NO OF CASES	PERCENTAGE
RTA	22	73%
FALL	**7**	24%
ASSAULT	1	3%
TOTAL	30	100%

Most of our cases occurred following RTA (73%), only to be followed by fractures due to fall (24%), and Assault (3%).

Graph 4



<u>FRYKMAN'S TYPE OF FRACTURES</u>:

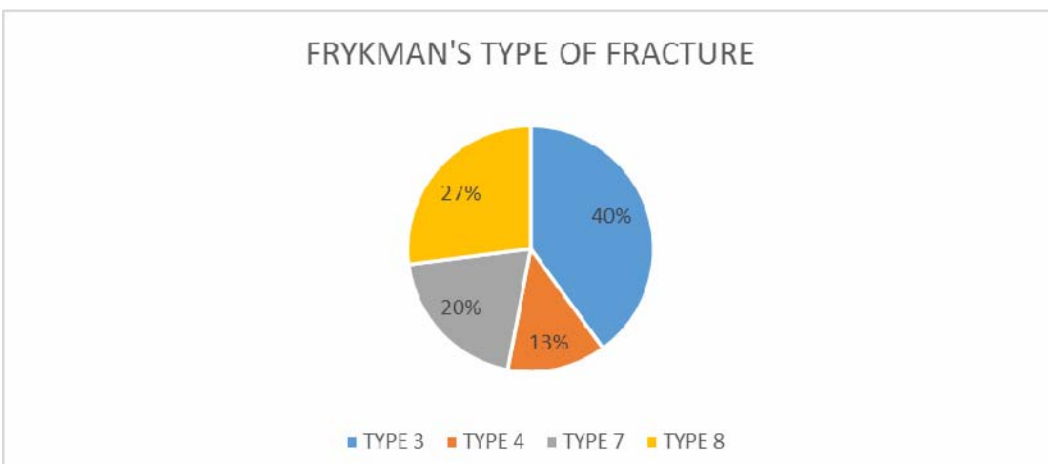
Distribution based on Frykman's classification of distal end radius fractures.

Table : 5

FRYKMANS TYPE	NO OF CASES	PERCENTAGE
Type 1	0	0
Type 2	0	0
Type 3	12	40%
Type 4	4	13%
Type 5	0	0
Type 6	0	0
Type 7	6	20%
Type 8	8	27%
TOTAL	30	100%

Most of our cases were of Type III constituting about 40%

Graph 5

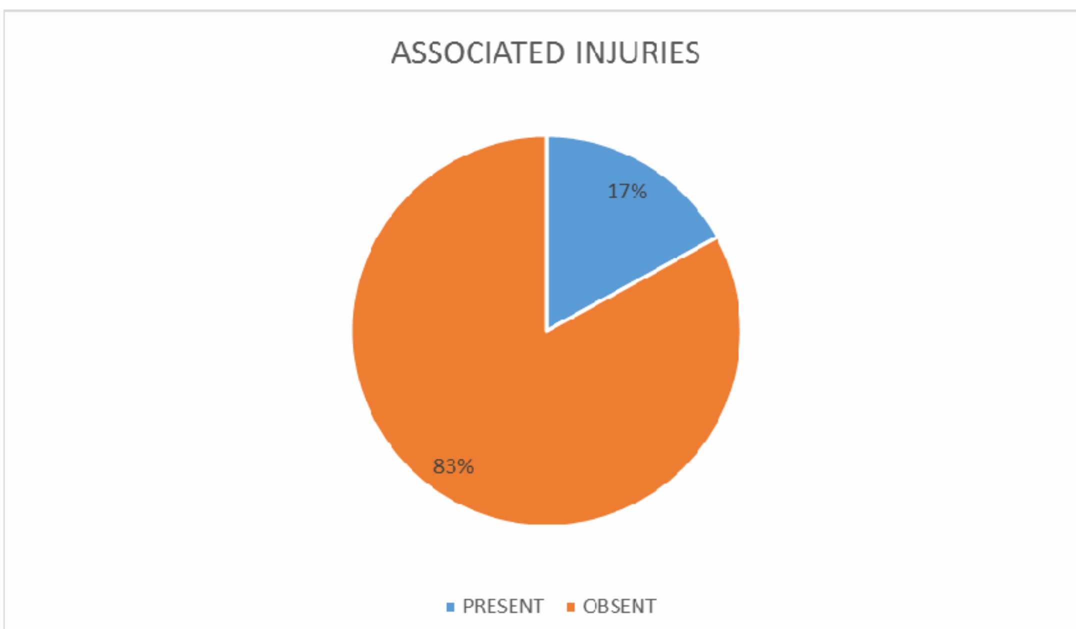


<u>ASSOCIATED INJURIES</u>:

In our study 5 of the cases (17%) had associated skeletal injuries.

1. Case no : 5 had associated ipsilateral patella fracture, distal end femur fracture and contralateral humerus fracture.
2. Case no : 7 had associated ipsilateral fracture shaft of proximal phalynx of 3rd and 4th fingers.
3. Case no : 9 had associated ipsilateral mid shaft of femur fracture.
4. Case no : 10 had associated ipsilateral fracture head of 1st metatarsal.
5. Case no : 22 had associated contralateral patella fracture.

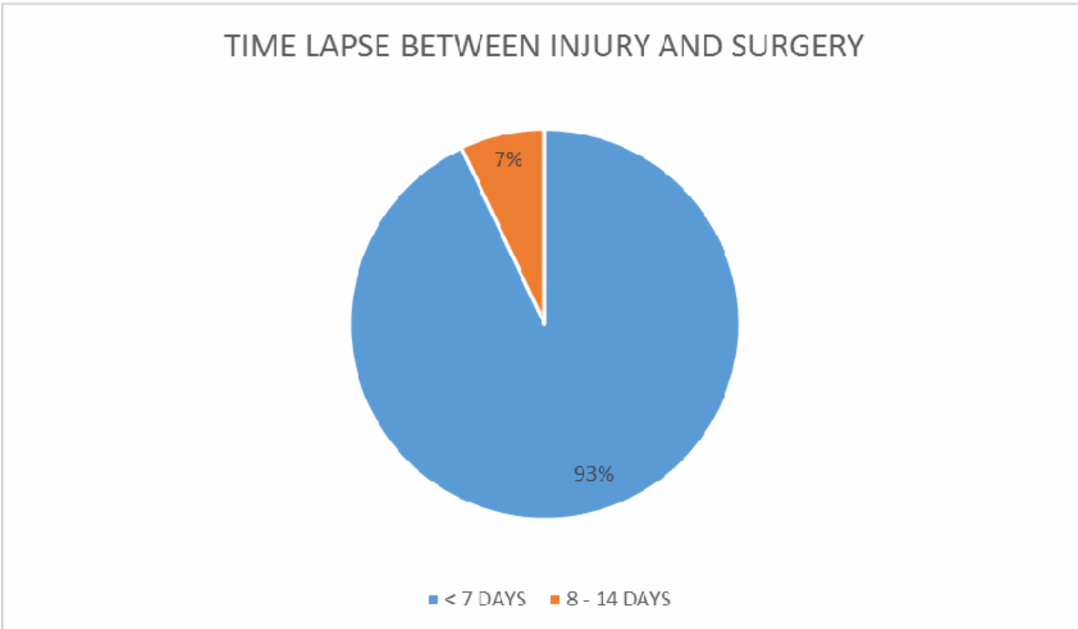
Graph 6



TIME LAPSE BETWEEN INJURY AND SURGERY:

Most of the cases were operated within 3 days of attending the OPD or the emergency. Out of the 30 cases, 28 (93%) cases were operated within a week of injury and 2 (7%) cases between 8 -14 days. The delay is because of late presentation of the patient.

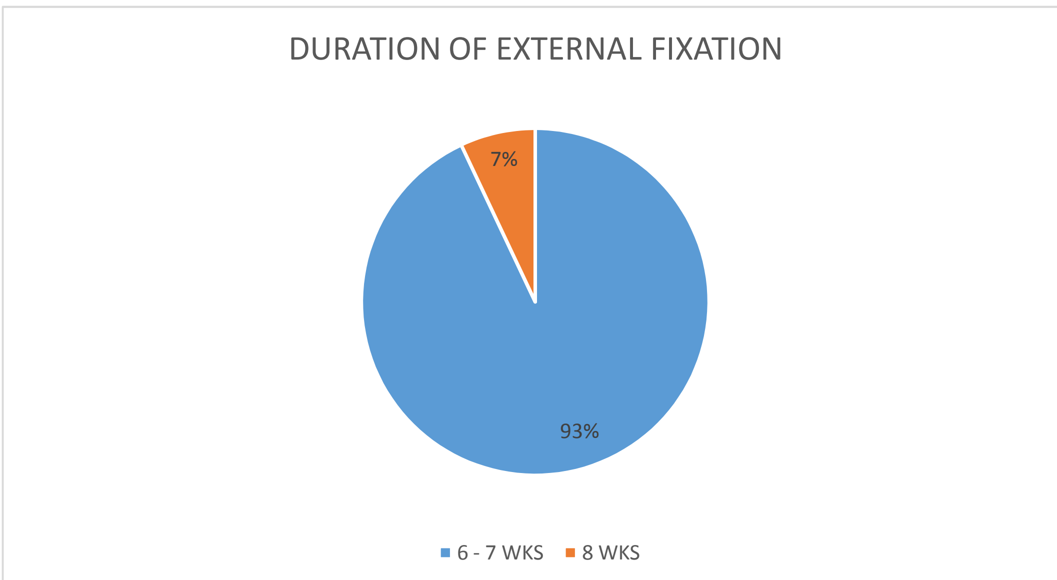
Graph 7



DURATION OF EXTERNAL FIXATION:

Duration of the external fixator in situ was for 6-7 weeks in 93% & in 7% of cases external fixator was left in place for 8 weeks. Mean duration of external fixator application was 6.3wks.

Graph 8



FOLLOW UP:

Most of our cases were followed up for a minimum period of 6 months. Average duration of follow up was 37.04 weeks. Average range of movement achieved

TABLE - 6

MOVEMENTS	AVERAGE MOVEMENT	NORMAL
Dorsiflexion	74.6^0	85^0
Palmarflexion	74.8^0	85^0
Radial deviation	13^0	15^0
Ulnar deviation	33.1^0	45^0
Pronation	75.5^0	85^0
Supination	76.5^0	85^0

COMPLICATIONS SEEN:

Table – 7

Associated complications

Complications	**No of cases**
Residual pain	4
Dorsal angulation	4
Pin tract infection	1
Pin loosing	0
Restricted wrist movements	4
Finger stiffness	1
Arthritis	0
Distal radioulnar instability	0
Sudecks dystrophy	1
Carpal tunnel syndrome	0
Non union	0

Residual wrist pain was seen in 4 patients associated with restriction of the wrist movements, Out of these 4 patients one patient had severe restriction of wrist movements affecting daily activities.

Sudeck's dystrophy was noted in 1case which subsided with physiotherapy and analgesics.

One patient had superficial pin-track infection which healed with oral antibiotics and aggressive pin-track care.

In one patient we noticed finger stiffness due to proximal phalynx fracture which was treated with k wire fixation.

RESULTS

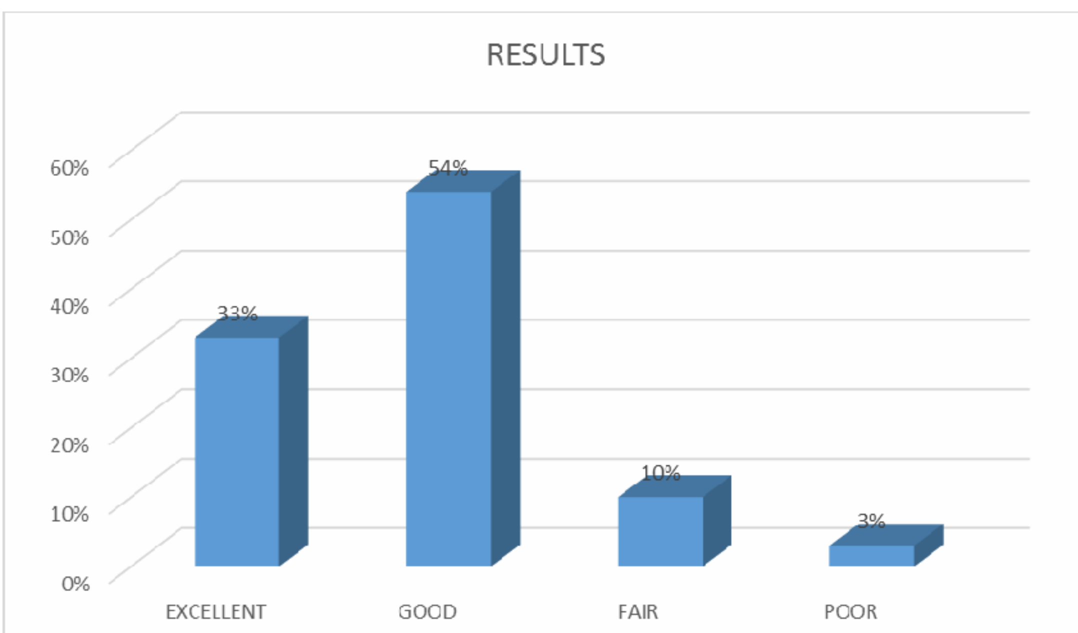
Results were assessed as per De merit point system of Gartland and Werley (modified by Sarmiento 1975)[75] for functional results at the end of 6 months of follow up.

Table - 8

Functional Results in our study

RESULT	NO OF CASES	PERCENTAGE
Excellent	10	33%
Good	16	54%
Fair	3	10%
poor	1	3%
TOTAL	30%	100%

Graph 9



1) Excellent: 10 patients had no pain and deformity There was no restriction of movement of wrist and forearm. They did not have any complications. Hence they were rated as excellent.

2) Good: 16 patients had no deformity of the wrist but had some limitation of wrist movements. They were rated as Good.

3) Fair: 3 patients had pain, limitation of movement at the wrist that was less than 50% of that of normal and the result was rated as fair.

4) Poor: 1 patient had dinner fork deformity with almost restriction of wrist movements, affecting markedly daily activities due inadequate follow up, patient turned up directly after 6 months for follow up and the result was rated as poor (Case No. 6).

Demerit point system of Gartland and Werly

RESULT	POINTS
Residual deformity	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	2-3
Point range	0-3
Subjective evaluation	
Excellent – no pain, disability or limitation of motion	0
Good - occasional pain, slight limitation of motion and no disability	2
Fair - occasional pain, some limitation of motion, feeling of weakness in wrist, no particular	4
Poor - pain, limitation of motion, disability and activities more or less markedly restricted	6
Point range	0-6
Objective evaluation	
Loss of dorsiflexion (45^0)	5
Loss of ulnar deviation (15^0)	3
Loss of supination (50^0)	2
Loss of palmar flexion (30^0)	1
Loss of radial deviation (15^0)	1
Loss of circumduction	1
Loss of pronation (50^0)	2
Pain in the distal radioulnar joint	1
Grip strength – 60% or less of opposite side	1
Point range	0-5

Complication

Arthritic change	
Minimum	1
Minimum with pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complication (median)	1-3
Poor finger function due to the cast	1-2
Point range	0-5

End result point range

Excellent	0-2
Good	3-8
Fair	9-20
Poor	Above 21

FIG 8 : X-RAYS & CLINICAL PHOTOGRAPHS

CASE NO 4

Pre Operative X-Rays

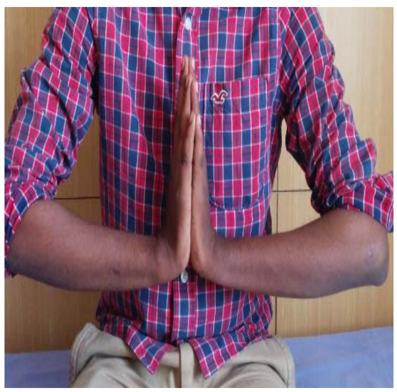
AP **Lateral**

Post Operative

6 Weeks **6 Months**

SUPINATION

PRONATION



DORSI FLEXION

PALMAR FLEXION

ULNAR DEVIATION

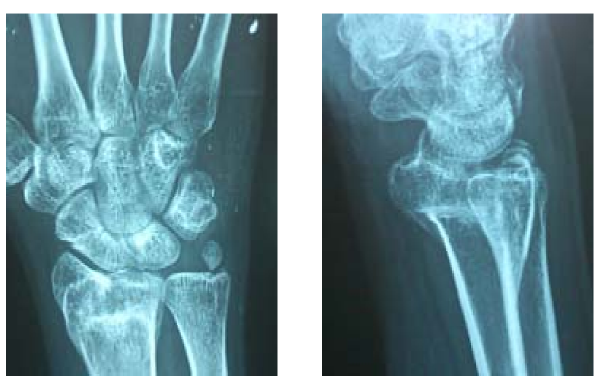
RADIAL DEVIATION

CASE 12

PRE OPERATIVE

POST OPERATIVE

6 MONTHS



DORSI FLEXION **PALMAR FLEXION**

PRONATION **SUPINATION**

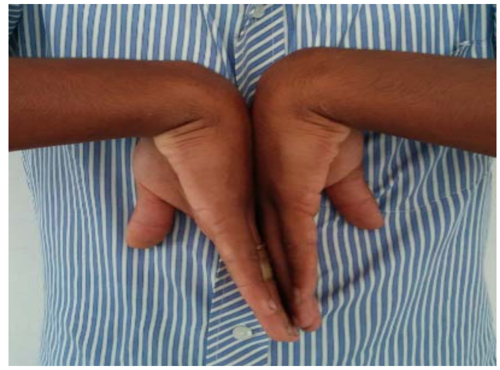
RADIAL DEVIATION **ULNAR DEVIATION**

CASE 13

PRE OPERATIVE

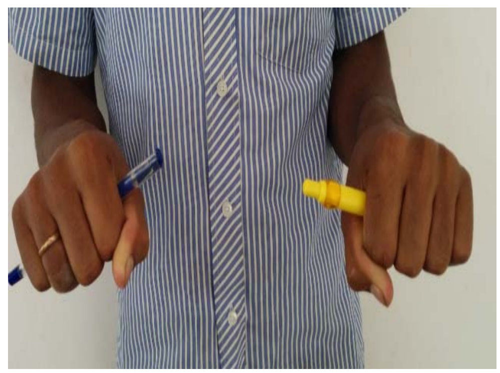
POST OPERATIVE

6 MONTHS



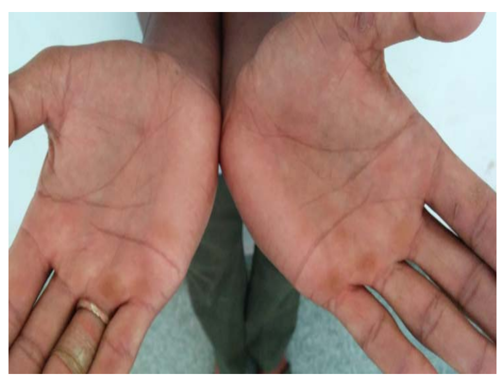
DORSI FLEXION

PALMAR FLEXION



SUPINATION

PRONATION



ULNAR DEVIATION

RADIAL DEVIATION

CASE NO 25

PRE OPERATIVE

POST OPERATIVE

6 MONTHS

PRONATION **DORSI FLEXION**

SUPINATION **PALMAR FLEXION**

RADIAL DEVIATION **ULNAR DEVIATION**

CASE 27

PRE OPERATIVE


POST OPERATIVE


6 MONTHS


DORSI FLEXION **PALMAR FLEXION**

SUPINATION **PRONATION**

ULNAR DEVIATION **RADIAL DEVIATION**

CASE NO 6

PRE OPERATIVE

POST OPERATIVE

6 MONTHS

DISCUSSION

It must be emphasized that this study is only short term follow up with average of 37.04 weeks and the discussion that follows is essentially a preliminary assessment.

The aim of this study is to evaluate the anatomical and functional results of external fixator for unstable distal end radius fractures. Most distal radial fractures are treated with closed reduction and cast applications. We treated distal end radius fractures by external fixator from November 2012 to April 2014.

Patients ranged from 18-74 years and the mean age was 38.06 years. The table below shows the mean age group of various studies. It shows that the incidence of unstable distal radius fracture was common in 4th decade.

Higher incidence in this age group probably is due to active life style which is prone for accidents and resulting in high velocity injury

Table - 9

Comparison of mean age groups of patient

Study group	**Mean Age group (years)**
Leung et al(1989)	35.6
Gunaki RB et al(1998)	34.8
Jain BK et al (1998)	37
Akmaz et al(2003)	41
Aggarwal et al(2004)	45
Our study	38.06

The incidence of fractures in our study was more common in males (70%) which can be attributed to the risk of injury due to occupational and ambulant life led by them. High incidence of fractures in males was also seen in studies of Leung et al (1989), Jain BK et al(1998), Mannur et al (2001), Yamamoto et al (2003), Nagi ON et al (2004).

In our study it was noted that dominant hand was more commonly involved (60%). This may be attributed to tendency of stretching the dominant hand as a reflex while RTA / fall so as to avoid injury to vital organs.

Out of 30 patients in 73% of our cases, the mode of injury was RTA, 24%of cases were due to fall over out stretched hand. RTA being major mode of injury. In Gunaki RB et al study 60% of cases were due to road traffic accident.

In our study associated skeletal injuries were present in 17% of cases. In that of Gunaki RB et al study more common associated injuries were head injury(2),tibia-fibula fractures(3).

In our study 6(20%) of fractures were open fractures, the incidence of open fracture is comparable to that observed in Jain BK et al study (18.1%).

As far as distribution of fractures according to Frykman's classification our indications for fracture of distal radius for external fixation are comparable to that of other standard studies. Most of our cases had a higher Frykman's type with Type III constituting 40%.

This is in concordance with other studies.

Table – 10

Comparison of studies based on Frykman's type of fracture

Frykman's Classification	Our study	Cooney 1979	Leung 1989	Nagi 2004	Aggarwal 2004	David Wei 2009
Type I	0	5%	1.4%	0	0	0
Type II	0	7%	4.2%	0	1.08%	0
Type III	40%	5%	8.3%	0	20.6%	8.5%
Type IV	13%	12%	18%	0	21.7%	11.4%
Type V	0	10%	11%	10%	3.2%	5.7%
Type VI	0	13%	9.7%	16.6%	4.3%	2%
Type VII	20%	20%	20.8%	33.3%	25%	17.1%
Type VIII	27%	28%	26.4%	40%	24%	57.1%
Total case	30	60	72	35	92	35

The average period of immobilization in our study was shorter (6.3weeks) as advised by Nagi ON et al[68] compared to that of Gunaki RB et al[52] wherein it was 7.2weeks. It was peculiarly noted that severely comminuted fractures and Frykman's type VIII required longer duration of immobilization than Frykman's type I to VII.

In our study the fixator was removed after radiological and clinical union on out patient basis without anaesthesia after 6-8 weeks. Physiotherapy was carried out regularly for 2 weeks. Most of the cases were followed up for a minimum of 6 months. The mean follow up was 37.04 weeks.

The radial shortening due to loss of reduction was measured as the difference between initial post reduction and final X ray made for each patient as suggested by Cooney et al (1979)[76] In our series average loss of radial length was 2.41 mm, slightly higher as compared to that of 2.13mm in David Eei et al (2009)[74]. It was also noted that loss of radial length increases with Type VII & VIII fractures.

Gunaki RB et al (1998)[52] series. The residual tilt depended upon extent of dorsal angulation before reduction and adequacy of restoration of palmar tilt after reduction.

Even small change in palmar tilt leads to radio carpal dysfunction as suggested by Taleisnik and Watson (1987)[52] and causes midcarpal instabilities due to change in load distribution. Even slight dorsal tilt increases dorsiflexion and decrease in palmar flexion because of shift of flexion-extension towards dorsal aspect.

Table - 11

Comparison of volar tilt achieved

Angle (deg)	**Our study**	**David ewi (2009)**
$>0^0$	60%	53.33%
0^0	27%	20%
$<0^0$	13%	26.66%
Total cases	30	30

Note: Volar tilt ($>0^0$); Dorsal tilt ($<0^0$)

$<10^0$ residual dorsal tilt is acceptable. Excellent function of wrist is achieved even if normal 11^0 palmar tilt is not achieved because of biomechanics of wrist. Inability of achievement of palmar tilt is short coming of uniplanar externalfixation which provides ligamentotaxis in one plane this is confirmed by cadaveric study of intra-articular fractures by Bartosh and Saldanha[52]. This short coming is overcome by multi planar ligamentotaxis and non bridging external fixation which provides facility for palmar translocation of fracture fragments without positioning of wrist in extreme flexion. Non ridging external fixation was not tried because of severe comminution of fractures.

In our study we noticed 2 cases with articular step off ≥2mm but we did not observe any arthritic changes probably due to shorter duration of follow up. It is evident that average range of wrist movement achieved in our study at final follow up were more than maximum requirements for daily activities (Sarmiento 1975), are also comparable with that of Gunaki RB et al[52] (1998) study.

Results were assessed as per De merit point system of Gartland and Werley (modified by Sarmiento 1975) for functional results and criteria for anatomical results by Sarmiento (1980) at the end of 6 months of follow up.

Table -12

Functional results compared with other standard studies

Study group	**Excellent to good**	**Fair to poor**	**Total cases**
Cooney WP et al	85%	15%	130
Leung KS et al (1989)	80%	20%	72
Jakim I et al (1991)	83%	17%	169
Gunaki RB et al (1998)	86%	14%	30
Kleina W et al (2000)	87%	13%	103
Nagi ON et al (2004)	74.28%	25.72%	35
Our study	87%	13%	30

CONCLUSION

In our study external fixator was used in 30 patients with comminuted, intraarticularfracture distal end of radius. Fixator was maintained for a duration of 6 weeks.

We had 10 excellent, 16 good, 3 fair and 1 poor result.

This series concludes that in younger age group [<50], ligamentotaxis by external fixation consistently results in a favourable outcome in the management of intra-articular distal end of radius fractures.

The rate of serious complications is low. With careful dissection and placement of the pins, injury to the superficial sensory branch of the radial nerve and extensor pollicis longus tendon can be avoided. Aggressive pin-tract care can prevent many superficial infections. Most complications are minor and easily treated and do not affect outcome.

The external fixator is simple and inexpensive. It effectively stabilizes fractures yet allowing for hand motion and prevents stiffness. When comminuted, intra-articular fractures are treated by conventional methods, pain and restriction of joint motion are not uncommon. Whereas when treated by ligamentotaxis by external fixator, anatomical reduction is predictably achieved at fracture site. Though some cases have residual joint stiffness, pain and arthritis can be prevented.

In conclusion EXTERNAL FIXATOR is the effective method in treating the unstable intra-articular fractures of the distal end of radius. It is important to have a tight purchase of the pin in the bone with minimal damage to surrounding tissue

SUMMARY

We studied 30 patients with comminuted intra-articular fracture distal end of radius prospectively treated with static external fixator. In our study,

1. The age of the patients ranged from 18 to 74 years.
2. 21 were men and 9 were women.
3. The mechanism of injury was motor vehicle accident (high impact) in 22, history of fall in 7 patients and history of assault in 1 patient.
4. The dominant side was injured in 18 cases, the nondominent side in 12 cases.
5. According to the Frykman's classification, 12 fractures were type 1II (40%), 4 were type IV (13%), 6 were type VII (20%), and 8 were type VIII (27%).
6. 5 patients with high impact type injuries had additional fractures.
7. The external fixator was maintained for at least 6 weeks.
8. Minimum duration of follow-up was 6months.
9. Favorable results were obtained in 87% of the cases, fair results in 10%, and poor results in 3%.
10. 1 patient had superficial pin-track infection which healed with oral antibiotics and aggressive pin-track care.

BIBLIOGRAPHY

1. David SR, Margaret MM, Distal-Radius and Ulna Fractures. Rockwood and Green's Fractures in Adults, chapter30, 7th ed 2010;1:845.
2. Melone CP Jr. Articular fractures of the distal Radius. Orthop Clin North Am.1984; 15: 217-236.
3. Melone CP Jr. Distal radius fractures: Patterns of articular fragmentation. Othop Clin North Am. 1993; 24 (2): 239-253.
4. Andrew H. Crenshaw, Edward AP, Fractures of the shoulder, Arm, and Forearm. Campbell's Operative Orthopaedics chapter 54,11th ed 2008 ; 3:3445
5. Boparai RPS, et al, Role of ligamentotaxis in management of comminuted intra/ juxta articular fractures, Indian J Orthop 2006; 40: 185-187.
6. Seitz WH Jr. External fixation of distal radius fractures: Indications and Technical Principles. Othop Clin North Am. 1993; 24 (2): 255-264.
7. Standring S. Gray‘s Anatomy – The Anatomical basis of Clinical practice. 39th edition. Elsevier Churchill Livingstone publication. 2005.
8. Berger RA, Gracia Elias M. General anatomy of the wrist. Chapter 1 in Biomechanics of the wrist joint. Springer-Verlag publication. 1991.
9. Palmer AK, Werner FW. The triangular fibrocartilage complex of the wrist – Anatomy and function. J Hand Surg. 1981; 6: 153-162.
10. Simic PM., Weiland AJ. Fractures of the distal aspect of the Radius: Changes in Treatment Over the past two decades. J Bone Joint Surg (Am). 2003; 85-A: 552-564.

11. Putnam MD, Seitz WH. Fractures of the distal radius. Chapter 20 in Rockwoodand Green‘s Fractures in Adults. Edited by Bucholz RW, Heckman JD.Lippincott Williams &Wilkins Publication. 2001: 815-867.
12. Charles A. G, Yuming Yin, Louis A. Gilula, a, Andrew J. F, and Martin IBl. Wrist Fractures: What the Clinician Wants to Know. Radiology. 2001;219:11;28 :: 28.
13. Sarmiento A, Pratt GW, Berry NC, Sinclair WF. Colles' Fractures: Functional Bracing in Supination. J Bone Joint Surg. 1975; 57-A: 311–317.
14. Frykman G. Fracture of the Distal Radius Including Sequelae—Shoulder-Hand-Finger Syndrome, Disturbance in the Distal Radio-Ulnar Joint, and Impairment of Nerve Function: A Clinical and Experimental Study. Acta Orthop Scand. 1967; 108(Suppl):1–153.
15. Fernandez DL. Fractures of the distal radius: Operative treatment. Instr Course Lect. 1993; 42: 73-88.
16. Crenshaw AH. Fractures of the Shoulder, Arm, Forearm. Chapter 54 in Campbell‘s Operative Orthopaedics, edited by Canale ST. Mosby Publications. 2003.
17. Melone CP Jr. Articular fractures of the distal Radius. Orthop Clin North Am.1984; 15: 217-236.
18. Lidstrom A. Fractures of the Distal End of the Radius: A Clinical and Statistical Study of End Results. Acta Orthop Scand. 1959; 41(Suppl): 1–118.
19. Szabo RM. Extra articular fractures of the distal radius. Orthop Clin North Am. 1993 April; 24 (2): 229-237.
20. Lipton HA, Wollstein R: Operative treatment of intraarticular distal radial fractures. Clin Orthop. 1996; 327:110-124.

21. Seitz WH Jr. External fixation of distal radius fractures. Indications and technical principles. Orthop C lin North Am. 1993; 24:255-64.

22. Rikli D, Kupfer K, Bodoky A: Long-term results of the external fixation of distal radial" fractures. J Trauma 1998;44: 970-976.

23. Capo, John T; Swan, Kenneth G Jr ; Tan, Virak . External Fixation Techniques for Distal Radius Fractures. Clinical Orthopaedics & Related Research 9 February 2006.

24. Tan, Virak; Capo, John; Warburton, Mark. Distal Radius Fracture Fixation with an Intramedullary NaiL Techniques in Hand & Upper Extremity Surgery. 2005 December; 9(4): 195-201.

25. Cheing, Gladys L. Y. Wan, Jolly W. H.; Lo, Sing Kai. Ice and pulsed electomagnetic field to reduce pain and swelling after distal radius fractures. Journal of Rehabilitation Medicine.2005 Nov; 37(6):372-377.

26. Catalano LW III, Barron OA, Glickel SZ. Assessment of Articular Displacement of Distal Radius Fractures. Clinical Orthopaedics & Related Research. 2004 June; 423: 79-84.

27. Kaempffe FA, Walker KM. External Fixation for Distal Radius Fractures:Effect of Distraction on Outcome. Clinical Orthopaedics and Related Research. 2000 Nov; 1 (380): 220-225.

28. Kaempffe FA, Wheeler DR, Peimer CA et al. Severe fractures of the distal radius: effect of amount and duration of external fixator distraction on outcome. J Hand Surg. 1993; 18-A: 33-41.

29. Cooney WP 3rd, Linscheid RL, Dobyns JH. External pin fixation for unstable Colles' fractures. J Bone Joint Surg Am. 1979 Sep; 61(6A):840-5.

30. Jonsson U. External fixation for redislocated Colles' fractures. Acta Orthop Scand. 1983 Dec; 54(6):878-83.

31. Vaughan PA, Lui SM, Harrington IJ, Maistrelli GL.Treatment of unstable fractures of the distal radius by external fixation. J Bone Joint Surg Br. 1985 May; 67(3):385-9.

32. Altissimi M, Antenucci R, Fiacca C, Mancini GB: Long-term results of conservative treatment of fractures of the distal radius. Clin Orthop 1986 May; (206): 202-10.

33. Knirk JL, Jupiter JB: Intra-articular fractures of the distal end of the radius in young adults. J Bone Joint Surg Am 1986 Jun; 68(5): 647-59.

34. Clyburn TA. Dynamic external fixation for commimuted intra-articular fractures of the distal end of the radius. J Bone Joint Surg 1987; 69-A: 248–254.

35. Leung KS, Shen WY, Leung PC, et al: Ligamentotaxis and bone grafting for comminuted fractures of the distal radius. J Bone Joint Surg Br 1989 Nov; 71(5): 838- 42.

36. Howard PW, Stewart HD, Hind RE, Burke FD. External fixation or plaster for severely displaced comminuted Colles' fractures? A prospective study of anatomical and functional results. J Bone Joint Surg Br. 1989 Jan; 71(1):68-73.

37. Kaukonen Jp, Karaharju E, Luthje P, Porras M. External fixation of Colles' fracture. Acta Orthop Scand. 1989 Feb; 60(1):54-6.

38. Abbaszadegan H, Jonsson U, Von Sivers K. Prediction of instability of Colles‘ fractures. Acta Orthop Scand. 1989; 60: 646-650.

39. Bartosh RA, Saldana MJ: Intraarticular fractures ofthe distal radius: a cadaveric study to determine if ligamentotaxis restores radiopalmar tilt. J Hand Surg [Am] 1990 Jan; 15(1): 18-21.

40. Stein H, Volpin G, Horesh Z, Hoerer D. Cast or external fixation for fractureof the distal radius. A prospective study of 126 cases. Acta-Orthop- Scand.1990 Oct; 61 (5): 453-456.

41. Seitz WH, Putnam MD, Dick HM. Limited open surgical approach for external fixation of distal radius fractures. J Hand Surg 1990; 15-A: 288-293.

42. Sanders RA, Keppel FL, Waldrop JI. External fixation of distal radial fractures: results and complications. J Hand Surg [Am].1991 May; 16(3):385-91.

43. Jakim I, Pieterse HS, Sweet MB. External fixation for intra-articular fractures of the distal radius. J Bone Joint Surg. 1991; 73-B (2): 302-306.

44. McQueen MM, Michie M, Court-Brown CM. Hand and wrist function after external fixation of unstable distal radial fractures. Clin Orthop. 1992 Dec; 285: 200-204.

45. Cooney WP. Fractures of the distal Radius: A modern Treatment based Classification. Orthop Clin North Am. 1993 April; 24 (2): 211-216.

46. Sommerkamp TG, Seeman M, Silliman J et al. Dynamic external fixation of unstable fractures of the distal part of the radius. J Bone Joint Surg 1994; 76A: 1149–1161.

47. Trumble TE, Schmitt SR, Vedder NB: Factors affecting functional outcome of displaced intra-articular distal radius fractures. J Hand Surg [Am] 1994 Mar; 19(2): 325-40.

48. Bishay M, Aguilera X, Grant J, Dunkerley DR. The results of external fixation of the radius in the treatment of comminuted intraarticular fractures of the distal end.J Hand Surg [Br]. 1994 Jun; 19 (3):378-83.

49. McQueen MM, Hajducka C, Court-Brown CM. Redisplaced Unstable Fractures Of The Distal Radius A Prospective Randomised Comparison Of Four Methods Of Treatment. J Bone Joint Surg. 1996; 78-B (3): 404-409.

50. Cannegieter DM, Juttmann JW. Cancellous Grafting And External Fixation For Unstable Colles‘ Fractures. J Bone Joint Surg. 1997; 79-B: 428-432.

51. McQueen MM. Redisplaced unstable fractures of the distal radius- A Randomized, Prospective Study Of Bridging Versus Non-Bridging External Fixation. J Bone Joint Surg 1998 July; 80-B (4): 665-669.

52. Gunaki RB; Ranka RP. Management of fractures of distal third of radius. Indian Journal of Orthopaedics. 1998 Oct; 32 (4): 242-246.

53. Davenport WC, Miller G, Wright TW: Wrist ligament strain during external fixation: a cadaveric study. J Hand Surg [Am] 1999 Jan; 24(1): 102-7.

54. Wolfe SW, Austin G, Lorenze M, et al: A biomechanical comparison of different wrist external fixators with and without K-wire augmentation. J Hand Surg [Am] 1999 May; 24(3): 516-24.

55. Kapoor H, Agarwal A, Dhaon BK. Displaced intra-articular fractures of distal radius: a comparative evaluation of results following closed reduction, external fixation and open reduction with internal fixation. Injury. 2000 Mar; 31(2):75-9.

56. Young BT, Rayan GM. Outcome following nonoperative treatment of displaced distal radius fractures in low-demand patients older than 60 years. J Hand Surg [Am]. 2000 Jan; 25(1):19-28.

57. Kleina W, DeÂeb W, Riegerc H, Neumanna HS, Joostenc U. Results of transarticular fixator application in distal radius fractures. Injury. 2000; 31: 71-3

58. Kapoor H, Agarwal A, Dhaon BK. Displaced Intra-articular Fractures of Distal Radius: A comparative evaluation of results following closed reduction, external fixation and open reduction with internal fixation. Injury 2000; 31: 75– 79.

59. Szabo R.Fractures of the distal Radius, Chapter 44 in Chapman‘s Orthopaedic Surgery, 3rd ed, edited by Chapman MW. Lippincott Williams & Wilkins, Philadelphia. 2000.

60. Kaempffe FA, Walker KM. External Fixation for Distal Radius Fractures:Effect of Distraction on Outcome. Clinical Orthopaedics and Related Research. 2000 Nov; 1 (380): 220-225.

61. Singh N, Lanlngkliana H, Singh KD. Percutaneous Kirschner wire fixation of displaced Colles' fracture. Indian Journal of Orthopaedics. 2001 Oct; 35 (4): 238-41.

62. Mehta JA, Slavotinek JP, Krishnan J. Local osteopenia associated with management of intra-articular distal radial fractures by insertion of external fixation pins in the distal fragment: prospective study. Journal of Orthopaedic Surgery 2002: 10 (2): 179–184.

63. Simic PM., Weiland AJ. Fractures of the distal aspect of the Radius: Changes in Treatment Over the past two decades. J Bone Joint Surg (Am). 2003; 85-A: 552-564.

64. Yamamoto K, Masaoka T, Shishido T, Imakiire A. Clinical results of external fixation for unstable Colles‘ fractures. Hand Surg. 2003; 8 (2): 193- 200.

65. Werber KD, Raeder F, Brauer RB, Weiss S. External Fixation Of Distal Radial Fractures: Four Compared With Five Pins: A Randomized Prospective Study. J Bone Joint Surg. 2003 April; 85-A (4): 660-667.

66. Akmaz I, Pehlivan O, Kiral A, Solakoglu C, Arpacioglu O. Short-term results of external fixation of unstable distal radial fractures. Acta Orthop Traumatol Turc. 2003; 37 (2): 126-32.

67. Catalano LW III, Barron OA, Glickel SZ. Assessment of Articular Displacement of Distal Radius Fractures. Clinical Orthopaedics & Related Research. 2004 June; 423: 79-84.

68. Nagi ON, Dhillon MS, Aggarwal S, Deogaonkar KJ. External fixators for intra-articular distal radius fractures. Indian Journal of Orthopaedics. 2004; 38: 19-22.

69. Aggarwal A, Rastogi A. External fixation for intra articular fracture distal end radius-a prospective study between bridging and non-bridging fixator. Indian Journal of Orthopaedics. 2004 Jan; 38 (1): 23-27.

70. Arora J, Kapoor H, Malik A, Bansal M. Closed reduction and plaster cast immobilization Vs External fixation in comminuted intra articular fractures of distal radius. Indian Journal of Orthopaedics. 2004; 38: 113-117.

71. Kreder HJ, Hanel DP, Agel J, McKee M, Schemitsch EH, Trumble TE, Stephen D. Indirect reduction and percutaneous fixation versus open reduction and internal fixation for displaced intra-articular fractures of the distal radius: A Randomised, Controlled Trial. J Bone Joint Surg. 2005 June; 87-B (6): 829-836.

72. Azzopardi T, Ehrendorfer S, Coulton T, Abela M. Unstable extra-articular fractures of the distal radius. A Prospective, Randomised Study Of

Immobilisation In A Cast Versus Supplementary Percutaneous Pinning. J Bone Joint Surg. 2005 June; 87-B (6): 837-840.

73. Germaine GQ Xu. Prospective Randomised Study of Intra-Articular Fractures of the Distal Radius: Comparison Between External Fixation and Plate Fixation Ann Acad Med Singapore 2009; 38:600-612.

74. Unstable Distal Radial Fractures Treated with External Fixation, a Radial Column Plate, or a Volar Plate. A Prospective Randomized tial Rosenwasser David H. Wei, Noah M. Raizman, Clement J. Bottino, Charles M. Jobin, Robert J. Strauch and Melvin P. *J Bone Joint Surg Am.* 2009; 91:1568-1577.

75. Sarmiento A, Pratt GW, Berry NC, Sinclair WF. Colles' Fractures: Functional Bracing in Supination. J Bone Joint Surg. 1975; 57-A: 311–317.

76. Cooney WP, Linscheid RL, Dobyns JH. External Pin Fixation for Unstable Colles' Fractures. J Bone Joint Surg. 1979; 61-A: 840–845.

ANNEXURES

PROFORMA

"STUDY OF MANAGEMENT OF UNSTABLE FRACTURE OF DISTAL END RADIUS USING EXTERNAL FIXATOR IN ADULTS"

CASE NO

NAME

AGE

SEX

OCCUPATION

ADDRESS

HOSPITAL NO

DATE OF ADMISSION

DIAGNOSIS

DATE OF SURGERY

DATE OF DISCHARGE

DATE OF REMOVAL OF EXTERNAL FIXATOR

DURATION OF TREATMENT

MODE OF INJURY

1. Road traffic accident
2. Industrial accident
3. Agricultural accident
4. Assault
5. Fall from height
6. Sports injury
7. Miscellaneous

HISTORY OF PRESENTING ILLNES

1. Mechanism of trauma
2. Duration
3. History of previous illness if any

METHOD OF FIRST AID GIVEN

GENERAL PHYSICAL EXAMINATION

Built- well/ moderate/ poor

Nourishment- well/ moderate/ poor

Pallor, Icterus, Cyanosis, Clubbing, lymphadenopathy, edema

Temperature- febrile/ non febrile

Pulse rate-

Blood pressure-

Respiratory rate-

SYSTEMIC EXAMINATION

1. R.S
2. C.V.S.
3. P/A
4. C.N.S.
5. SPINE
6. PELVIS

LOCAL EXAMINATION

SYMTOMS

SWELLING

PAIN

DEFORMITY

LOSS OF FUNCTION

ASSOCIATED SOFT TISSUE AND SKELETAL INJURY

SINGS

SWELLING

DEFORMITY

TENDERNESS

ABNORMAL MOBILITY

CREPITUS

MOVEMENTS

1) AT THE WRIST

FLEXION

EXTENSION

RADIAL DEVIATION

ULNAR DEVIATION

2) AT THE FORE ARM

SUPINATION

PRONATION

3) AT THE ELBOW

FLEXION

EXTENSION

COMPLICATIONS

NUROLOGICAL

VASCULAR

MUSCULAR

TREATMENT

SURGERY

HOW MANY PINS USED

POSITION OF FOREARM

ANAESTHESIA

DURATION OF FIXATION

ANTIBIOTICS

COMPLICATIONS OF SURGERY

NVD

DISTRACTION

PINTRACT INFECTIONS

LOOSENING OF PINS

ADVICE ON DISCHARGE

FOLLOW UP WITH X RAYS AT 1, 6, AND 8 WEEKS AND 3 , 6, MONTHS

WKS	FOLLOW UP	TENDERNESS	D.F	P.F	SUPINATION	PRONATION	U.D	R.D	FINGER MOVEMENTS	COMPLICATIONS
1										
4-6										
8										
12										
24										

RESULT:

INFORMED CONSENT

I, ______________________ have been told about the study in a language that I understand (_____________). I have been told that this is for a dissertation procedure, that my participation is voluntary and I he/she reserve the full right to withdraw from the study at my own initiative at any time, without having to give any reason, and that decision to participate or withdraw from the study at any stage will not prejudice my/his/her, rights and welfare. Confidentiality will be maintained and only be shared for academic purposes.

I hereby give consent to participate in the above study. I am also aware that I can withdraw this consent at any later date, if I wish to. This consent form being signed voluntarily indicates agreement to participate in the study, until I decide otherwise.

I have signed this consent form, before my participation in this study.

Signature of the subject:

Date:

Place:

I, Dr. M.C. Vinod Kumar Reddy, Post graduate student in Department of Orthopaedics conducting a dissertation work for award of MS degree in Orthopaedics. The study topic is "*Study of Management of Unstable Fracture of Distal End Radius Using Externalfixator in Adults*"

I hereby state that the study procedures were explained in detail and all questions were fully and clearly answered to the above mentioned participant /his/her relative.

Investigators signature:

Date:

Place:

MASTER CHART

SL NO	NAME	HOSPITAL NO	AGE	SEX	SIDE OF INJURY	TYPE OF INJURY	MODE OF INJURY	FRYKMANS TYPE	ASSOCIATED INJURIES	TIME GAP B/W INJURY & SURGERY	EXTERNAL FIXATOR DURATION IN WKS	DF	PF	RD	LD	PRONATION	SUPINATION	PAIN	ARTHRITITS	COMPLICATIONS	RESULT
1	GOPAL	812938	45	F	LEFT	CLOSED	FALL	4	ABSENT	1	6WKS	85	85	15	40	85	85	NIL	NIL	-	EXCELLENT
2	ANWAR KHAN	836281	22	M	RIGHT	CLOSED	FALL	7	ABSENT	2	7WKS	75	80	15	35	80	80	NIL	NIL	SUDECKS DYSTROPHY	GOOD
3	KANDHAMMA	848173	74	M	RIGHT	CLOSED	FALL	8	ABSENT	2	6WKS	70	75	10	35	80	85	NIL	NIL	-	GOOD
4	RAMACHANDHARA	849650	40	M	LEFT	CLOSED	RTA	8	ABSENT	1	6WKS	80	85	15	35	85	85	NIL	NIL	-	EXCELLENT
5	VEERABADRA	870309	22	M	RIGHT	CLOSED	RTA	3	PRESENT	1	6WKS	85	80	15	40	85	85	NIL	NIL	-	EXCELLENT
6	DOODA VENKATESHA	877192	35	M	LEFT	OPEN	RTA	8	ABSENT	1	6 WKS	40	30	5	15	45	45	On exe	NIL	DEFORMITY	POOR
7	SUMITHRAMMA	883223	40	F	LEFT	OPEN	RTA	3	PRESENT	1	6WKS	70	80	10	35	75	80	NIL	NIL	FINGER STIFNESS	GOOD
8	VEDHANAYAKI	897567	55	F	LEFT	OPEN	RTA	3	ABSENT	1	6WKS	70	70	10	25	80	80	NIL	NIL	-	GOOD
9	SRIDEVI	898545	35	F	RIGHT	CLOSED	RTA	7	PRESENT	1	6WKS	55	50	10	25	65	70	On exe	NIL	RESIDUAL PAIN	FAIR
10	HARISH KUMAR	907052	25	M	RIGHT	CLOSED	RTA	4	PRESENT	1	6WKS	75	80	15	30	70	75	NIL	NIL	-	GOOD
11	SHILPA	915309	24	F	LEFT	CLOSED	RTA	3	ABSENT	2	6WKS	85	85	15	45	80	85	NIL	NIL	-	EXCELLENT
12	VIKAS	927160	21	F	RIGHT	CLOSED	FALL	8	ABSENT	3	6WKS	70	80	15	35	75	75	NIL	NIL	-	GOOD
13	GOPALAKRISHANA	944402	27	M	RIGHT	CLOSED	RTA	3	ABSENT	5	7WKS	85	80	15	40	85	80	NIL	NIL	-	EXCELLENT
14	MANJUNATH	945665	32	M	RIGHT	CLOSED	RTA	3	ABSENT	2	7WKS	75	75	10	30	75	80	NIL	NIL	-	GOOD
15	NAGARAJ	946235	28	M	LEFT	CLOSED	RTA	7	ABSENT	1	6WKS	80	85	15	45	85	85	NIL	NIL	-	EXCELLENT
16	BALAPPA	952652	44	M	RIGHT	CLOSED	RTA	3	ABSENT	1	6WKS	70	80	15	35	80	75	NIL	NIL	PINTRACT INFECTION	GOOD
17	JAYAMMA	952811	38	M	LEFT	CLOSED	RTA	3	ABSENT	10	7WKS	80	75	15	30	80	75	NIL	NIL	-	GOOD
18	SAROJA	953812	60	F	RIGHT	CLOSED	FALL	4	ABSENT	2	6WKS	75	80	10	30	80	75	NIL	NIL	-	GOOD
19	BHAGHYAMMA	956334	44	F	RIGHT	OPEN	RTA	3	ABSENT	2	6WKS	85	80	15	40	85	85	NIL	NIL	-	EXCELLENT
20	LAKSHMI	961761	35	F	LEFT	CLOSED	RTA	8	ABSENT	1	8WKS	60	65	10	20	70	70	On exe	NIL	RESIDUAL PAIN	FAIR
21	NARASIMHA	962271	48	M	RIGHT	CLOSED	RTA	3	ABSENT	3	6WKS	85	80	15	40	80	80	NIL	NIL	-	EXCELLENT
22	ERAPPA	962283	36	M	RIGHT	OPEN	RTA	8	PRESENT	2	7WKS	65	60	10	25	70	70	On exe	NIL	RESIDUAL PAIN	FAIR
23	SHANKAR	962710	47	M	RIGHT	OPEN	RTA	4	ABSENT	2	6WKS	80	70	15	30	75	80	NIL	NIL	-	GOOD
24	VIJAY KUMAR	963985	62	M	LEFT	CLOSED	FALL	3	ABSENT	1	6WKS	85	85	15	45	80	85	NIL	NIL	-	EXCELLENT
25	GOPALAPPA	968832	55	M	RIGHT	CLOSED	FALL	8	ABSENT	12	8WKS	70	75	15	30	65	75	NIL	NIL	-	GOOD
26	NARAYANAPPA	1E+06	19	M	RIGHT	CLOSED	RTA	7	ABSENT	5	6WKS	80	70	10	30	65	70	NIL	NIL	-	GOOD
27	SHAIK SAHEEL	1E+06	39	M	LEFT	CLOSED	RTA	7	ABSENT	1	6WKS	75	75	15	35	70	65	NIL	NIL	-	GOOD
28	SRAVAN KUMAR	1E+06	28	M	RIGHT	CLOSED	ASSAULT	3	ABSENT	1	6WKS	80	80	15	35	80	80	NIL	NIL	-	EXCELLENT
29	MUNIYAPPA	628	44	M	LEFT	CLOSED	RTA	8	ABSENT	1	6WKS	70	75	10	25	70	65	NIL	NIL	-	GOOD
30	AMBARISH	4607	18	M	RIGHT	CLOSED	RTA	7	ABSENT	2	7WKS	80	75	15	35	65	70	NIL	NIL	-	GOOD