A PROSPECTIVE STUDY OF DIFFERENT TYPES OF FIXATION OF INTRA ARTICULAR FRACTURE OF DISTAL RADIUS IN ADULTS

Dissertation submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment of the regulations

for the award of the degree of

MASTER OF SURGERY (M.S)

BRANCH – II – ORTHOPAEDIC SURGERY

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APRIL – 2020

CERTIFICATE FROM THE INSTITUTION

This is to certify that this dissertation, titled, **"DIFFERENT TYPES OF FIXATION OF INTRA ARTICULAR FRACTURE OF DISTAL RADIUS IN ADULTS"** submitted by Dr.Thangadurai D.K, post graduate student in Department of Orthopaedics and Traumatology, Thanjavur Medical College and Hospital Thanjavur,appearing for M.S.degree (Orthopaedics) Branch II examination in April 2020 is a bonafide record of work done by him as partial fulfilment of the regulations of The Tamilnadu Dr.M.G.R.Medical University,Chennai. I forward this to the Tamilnadu Dr.M.G.R Medical University,Chennai,Tamilnadu.

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This is to certify that this dissertation, titled, **"DIFFERENT TYPES OF FIXATION OF INTRA ARTICULAR FRACTURE OF DISTAL RADIUS IN ADULTS"** is a bonafide work done by **Dr.D.K.THANGADURAI**, under my supervision and guidance, during the tenure of his course period between May 2017 – September 2019, under the regulations of, **THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY, CHENNAI.**

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I, **Dr.Thangadurai D.K**, do solemnly declare, that this dissertation **"DIFFERENT TYPES OF FIXATION OF INTRA ARTICULAR FRACTURE OF DISTAL RADIUS IN ADULTS"**, is a bonafide record of work done by me, in the Department of Orthopaedics and Traumatology, Thanjavur Medical College, Thanjavur, under the supervision of my Professor and Head of Department **DR.A.BHARATHY, M.S.ORTHO, D.ORTHO, FRCS(Edin),** between May 2017 to September 2019. This dissertation is submitted to the Dr. M.G.R. Medical University, Chennai, in partial fulfilment of the University's regulations, for the award of M.S. Degree (Branch – II) in Orthopaedics, to be held in April 2020.

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submitted by Dr. K. THANGADURAI **of**

Dept. of ORTHOPAEDICS **Thanjavur Medical College, Thanjavur**

was approved by the Ethical Committee.

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Dated : 27.09.2017

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Urkund Analysis Result

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SYNOPSIS

ABSTRACT

Comminuted distal radius fracture in adults are challenging to treat.48 successive patients with Closed comminuted fracture of distal radius (26 males and 22 females)were treated.They include AO Type B(n=27) and AO type C(n=21) treated with Volar plating,External fixation and K-wire with plaster immobilization.Presence of skin abrasion decide the types of fracture.At one year follow up acceptable results were found in 15/19 of volar plating ,12/14 of external fixation and 14/15 of K-wire fixation.Complications like pin site infection,radial sensory nerve deficit,intra articular screw migration,keloid formation were seen.The results of the management of 3 methods are the same but complications are less and patient compliance are better with volar plating.

INTRODUCTION

Distal radius fracture continues to be most common skeletal injuries treated by orthopaedic surgeon. It comprises 1/6th (16 percentage) of all fractures seen and treated in an emergency room . Comminuted fractures of distal radius has bimodal type of age distribution. Fractures in adolescents and young adults are the result of high-energy trauma such as sports injuries, fall from heights or road traffic accidents. Elderly female are more liable to distal radius fracture due to severe post menopausal osteoporosis and higher tendency to fall when compared to same aged men. In distal radius the metaphyseal widening zone(corticocancellous junction) is more predisposed to fractures because lower amount of strong cortical bone and higher amount of weak cancellous bone. Most distal radius fractures are relatively uncomplicated and can be effectively managed conservatively. However intrarticular and unstable fracture can jeopardize the articular congruence integrity and kinematics of the articular surface. There is a consensus that 90 percentage of all distal radius fracture are articular injuries resulting in disruption of both radioulnar and radiocarpal joint. About 50% of metaphyseal fracture have intraarticular extension. Intraarticular fracture distal radius are inherently unstable and it is very difficult to reduce them anatomically and immobilize with cast or slab support . Also the associated complications are very high like pain ,loss of wrist motion, decreased grip strength etc. Articular congruity preservation and maintenance of radial length is the main prerequisite for successful treatment and recovery. The best method to obtain and to maintain the accurate anatomic reduction and articular congruity remains the topic of controversy . Since it involves the joint surface , and are very small fragments to fix ,distal radius fracture is an challenge to the orthopaedic surgeon.With the better understanding of

1) Biomechanics of wrist and fracture pattern
2) Treatment oriented Radius classification system
3) Availability of variety of fixation devices

has made the surgical treatment of distal radius articular fractures to have more favourable outcome and thus by minimizing the complication rates. There are fragment specific fixation devices like Lateral column plate, and common plate for all the fragments.

We propose to study the results of various fixation methods in intra articular fracture of distal radius.

ANATOMY OF THE WRIST

Bone and joint anatomy:

The distal end of the radius and ulna with eight carpal bones and the proximal ends of the five metacarpals together make up the wrist joint (Fig. 1)[1] The radius is located on the outer side of the forearm. Its distal end thickens and in the transverse direction widens. It has, in cross section, a quadrilateral shape and extends laterally into an easily palpable styloid process of the radius. On the medial side of the distal end of the radius is a shallow notch (the so-called Sigmoid notch or incisura ulnaris) with joint surface for engagement with the smooth circumference of the head of the ulna. The head of the ulna extends in a dorsoulnar direction into a slim ulnar styloid process that is also easily palpable. The entire distal end of the radius is with palmar bowing. Its volar surface is smooth and slightly concave. The dorsal and lateral surface of the distal radius are convex, rough and deepen into longitudinal grooves, which are separated by bone edges, for extensor tendons. The largest of these is called Lister's tubercle, which is located between the grooves for the tendon of extensor carpi radialis longus (ECRL) and the tendon of extensor pollicis longus (EPL). This tubercle is very well palpable [2].In front of the Lister's tubercule is a ScaphoLunate junction. Along with these two bones ,Triquetrum and Pisiform form the proximal row of the carpal bones. In the distal row, from radial to ulnar side, are the Trapezium, Trapezoid, Capitate, and Hamate. The Scaphoid, Lunate and Triquetrum with the distal articular surface of the radius, along with the articular disk between them, constitute the radiocarpal joint, that articulates during extension and flexion as well as radial and ulnar deviation of the hand (Fig. 1).

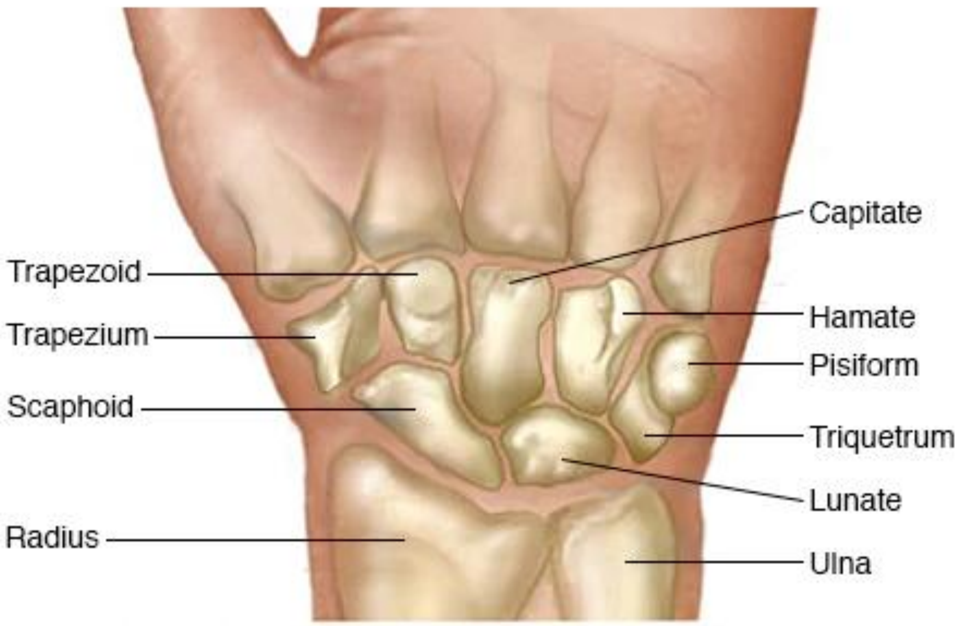


Fig 1:Bone anatomy of wrist

There are two facets on the articular surface of the distal end of the radius separated by a sagittal ridge. Fig 2

1)Triangular scaphoid articular facet (Scapohoid fossa) articulates with the scaphoid on the radial side of the radius

2) Oval lunate articular facet (Lunate fossa) articulates with the lunate on the ulnar side of the distal radius.

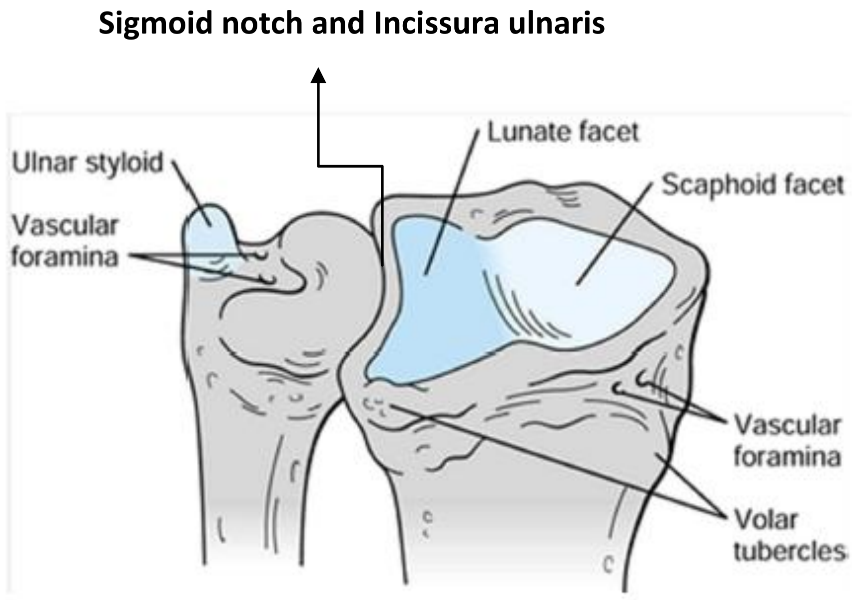


Fig 2:Articular facets of distal radius

The distal radioulnar joint (DRUJ) consists of the radial Sigmoid notch on the ulnar side of the distal radius, ulnar head, dorsal and palmar joint capsules, and the triangular fibro cartilage complex (TFCC). DRUJ allows pronation-supination movement that indicates combination of relative rotation between the radius and ulna around rotation axis, and translation between the radial sigmoid notch and the ulnar head. The ulna maintains its position relative to the rest of the forearm while the radius rotated about the rotation axis during supination and pronation.

TRIANGULAR FIBROCARTILAGE COMPLEX (TFCC)

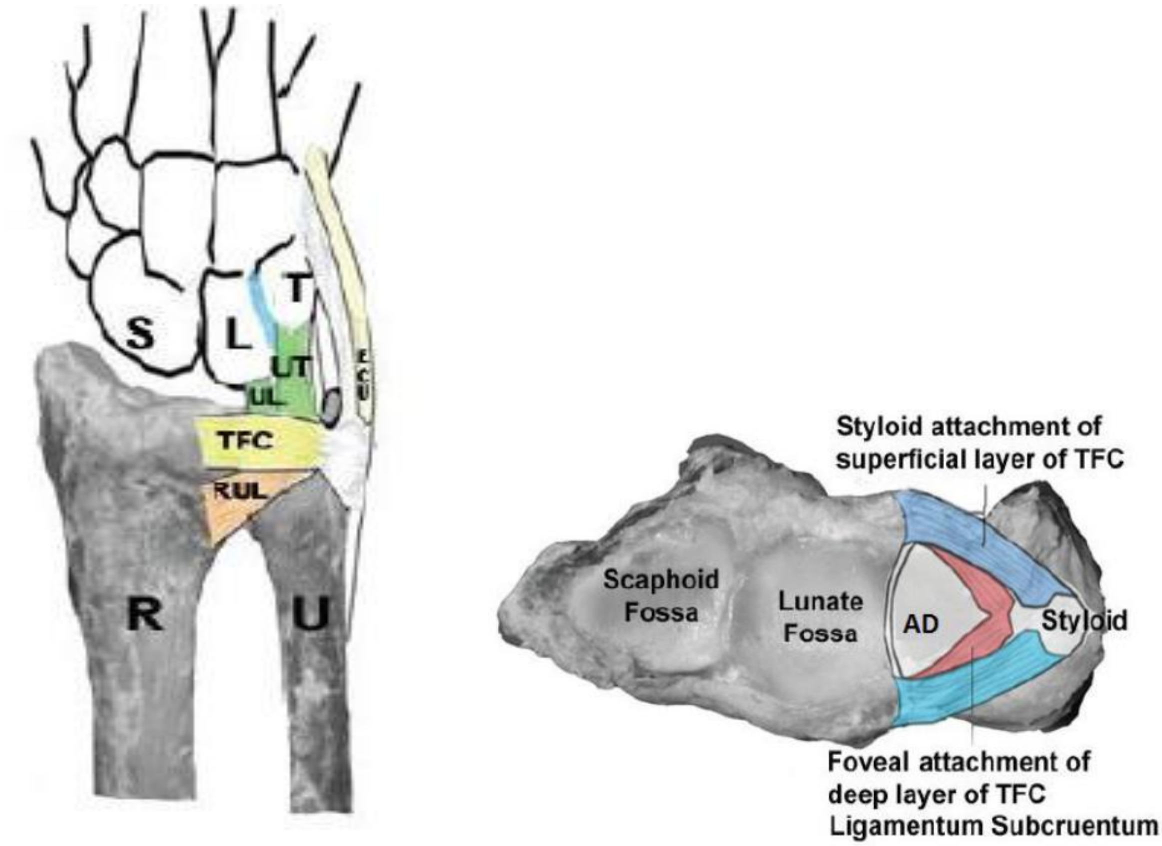


Fig 3: **a)**Diagrammatic representation of the TFCC, **b)** Diagrammatic representation of TFC inserting into the fovea (deep layer) and ulnar styloid (superficial layer), RUL: Radioulnar ligament, TFC: triangular fibrocartilage, UL: ulnolunate ligament, UT: Ulnotriquetral ligament, ECU: extensor carpi ulnaris in its subsheath, SP: styloid process of ulna providing attachment to these structures- R: Radius, U: Ulna, S: scaphoid, L: lunate, T: triquetrum, AD: articular disc.

The TFCC consists of

1. Triangular fibrocartilage (TFC)
2. Ulnolunate ligament
3. Ulnotriquetral ligament
4. The capsule
5. The ulnar collateral ligament and
6. The sheath floor of the extensor carpi ulnaris (ECU)

The TFC originates from the Sigmoid notch of the distal end of the radius and from the lunate and inserts into the base of the ulnar styloid process.(Fig: 3)[3,4,5]. The peripheral portion of the TFC is composed of the thick and well-vascularised dorsal and palmar radioulnar ligaments. Its central portion (ligamentum subcreuntum, meniscus homologue), that articulates with the distal ulna and the triquetrum, is avascular, load-bearing, and often likened to the meniscus of the knee. The TFCC is a load distributor between ulna and ulnar carpus, and stabilizer of the DRUJ and ulnocarpal joints. It also provide smooth forearm rotation. The DRUJ is a complex articulation dependent upon both bone and soft tissue stability. The TFCC disruption can cause DRUJ instability and functional impairment because of ulnar-sided wrist pain and decreased grip strength. Increasing attention has been given to the diagnosis and treatment of injuries in this area to maximize clinical, radiographic, and functional outcomes.

Anatomy of Ligaments

The ligaments of the wrist can be classified into two groups:

Extrinsic and Intrinsic.

The **extrinsic** ligaments bridge the radiocarpal and midcarpal joint.

There are three volar radiocarpal ligaments: (Fig 4)

1) RadioScaphoCapitate

2Long RadioLunate and

3) Short RadioLunate ligaments.

The volar ulnocarpal ligaments (UlnoLunate, UlnoCapitate and UlnoTriquetrate), in conjunction with the TFC, ulnar collateral ligaments, and the sheath of the ECU, make up the TFCC.

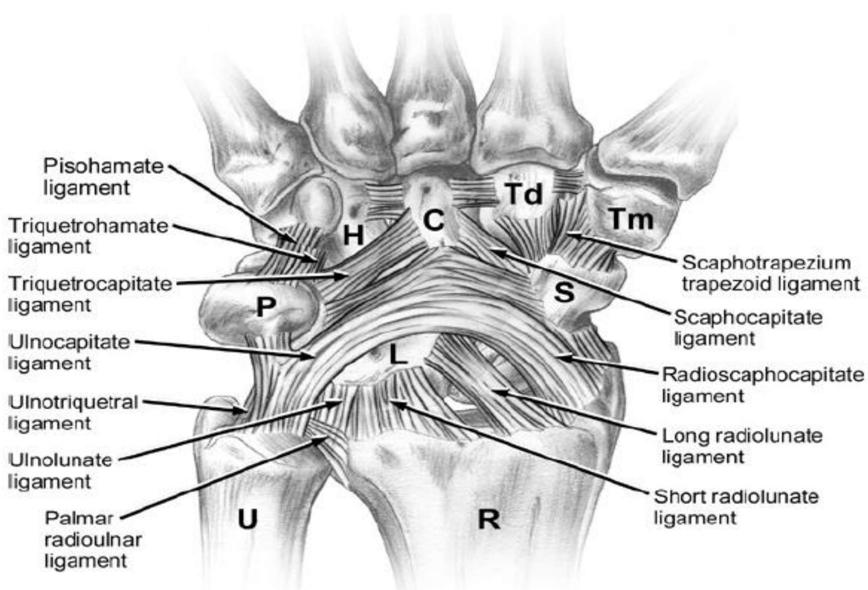


Fig 4:Palmar ligaments

Dorsally there are two important ligaments: (Fig:5)

1) Dorsal intercarpal ligament and

2) Dorsal radiocarpal ligament.

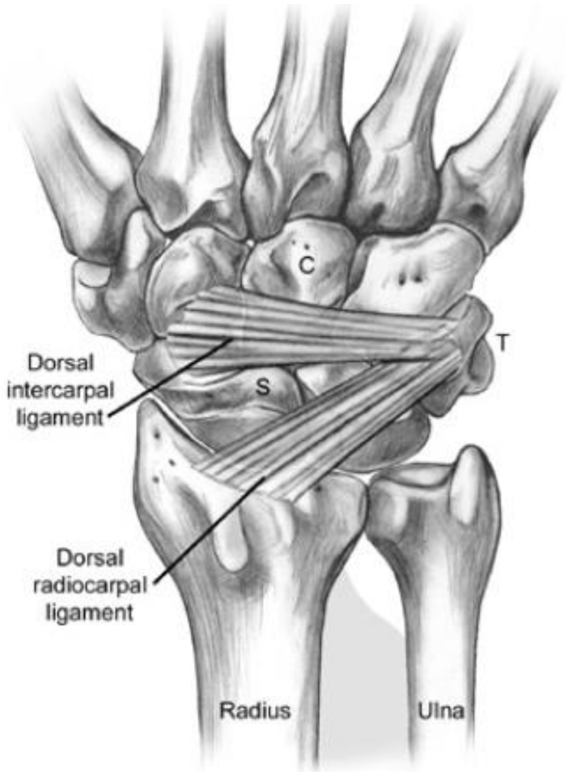


Fig.5.Dorsal Ligaments

The ulnar and radial collateral ligaments support the side stability of the wrist. The intrinsic ligaments connect adjacent carpal bones to each other providing stability to the base of the hand.

The two most important **intrinsic** ligaments are the

1.ScaphoLunate

2.LunoTriquetral ligaments

Neurovascular anatomy:

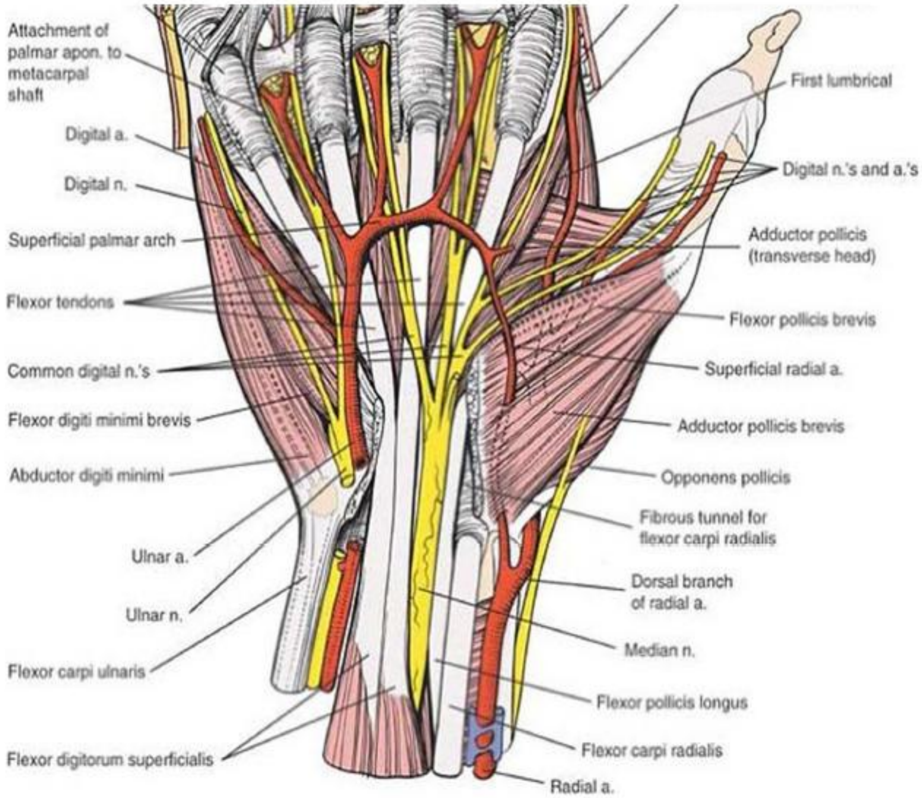
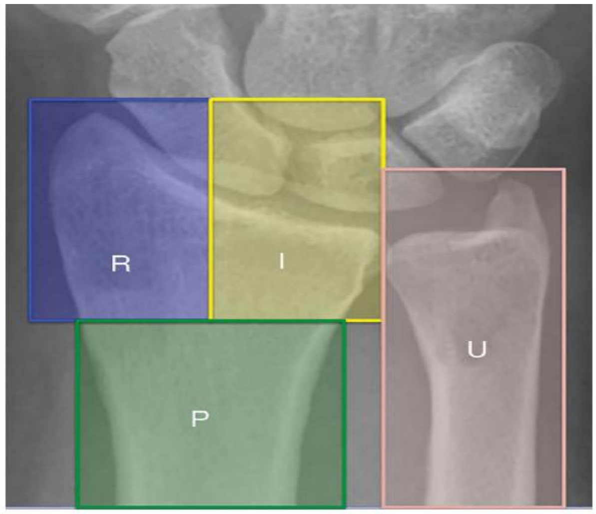


Fig :6 Neurovascular anatomy of wrist

The radial artery lies anterior to the pronator quadratus muscle and the distal end of the radius lateral to the flexor carpi radialis muscle. It leaves the forearm by winding lateral to radial styloid.(Fig:6) The radial pulse can be felt by gently palpating the radial artery against the underlying muscle and bone.The ulnar artery often remains tucked under the anterolateral lip of the flexor carpi ulnaris tendon and enters the hand by passing lateral to the pisiform bone and superficial to the flexor retinaculum of the wrist, and arches over the palm .The median nerve becomes more superficial in position at the level of the distal radius, lying between the tendons of the palmaris longus and flexor carpi radialis muscles. It leaves the forearm and enters the palm of the hand by passing through the carpal tunnel deep to the flexor retinaculum.

The ulnar nerve lies lateral to flexor carpi ulnaris nerve and enters the hand, by passing superficial to the flexor retinaculum, medial to ulnar artery and immediately lateral to the pisiform bone.The superficial branch of the radial nerve lies on the lateral aspect of the wrist in close association with the brachioradialis tendon.

THREE COLUMN CONCEPT



PA radiograph demonstrating the column model of the distal radius and ulna. I = intermediate column, P = pedestal, R = radial column, U = ulnar column.

Fig:7 .Three column model Distal radius

The '3-column model' of the distal forearm is a simple concept that aids understanding some typical features of distal radial fractures and its injury mechanism, and assists in planning internal fixation . [6] (Fig:7)

Lateral Column(Radial): includes the radial styloid and the scaphoid fossa. It serves primarily as a stabilizer, and as an insertion for the stabilizing capsular ligaments.

Intermediate Column: includes the ulnar side of the radius, lunate fossa and the sigmoid notch. It serves primarily for load transmission. Axial loads from the lunate and the proximal pole of the scaphoid are directed along this column.

Therefore, its accurate reconstruction is very important for stability and correct functioning of the radiocarpal and distal radioulnar joint.

Medial Column(Ulnar): is the stabilizing pivot of the wrist and includes the ulnar head, TFCC, and DRUJ. Approximately, half of the load is transmitted across the TFC.

Based on the theory of the three columns the intra-articular distal radial fractures consist typically of three main fragments:

1) Radial styloid process (radial column)

2)Ulnodorsal fragments (ulnar column)

3) Ulnovolar fragments (intermediate column).

According to the direction and amount of the applied force, the ulnar styloid process, TFCC or/and DRUJ can subsequently be injured. Injury of the TFCC and the subsequent DRUJ instability can occur as a result of the distal radial fracture. The injury mechanism is principally caused by traumatic axial load with rotational stress.

HISTORY AND REVIEW OF LITERATURE OF RADIUS FRACTURE FIXATION DEVICES

Fractures of the distal radius have been reported in literature for over centuries. Hippocrates diagnosed any displacement of the wrist following injury as dislocation due to the absence of fracture character like crepitus, paradoxical mobility, edema etc.

Pouteau in late 18th century, pointed out that the fractures of the distal end of radius were falsely diagnosed as wrist dislocations. [7]

In 1814,Abraham Collesdescribed the dorsally displaced distal radius fracture that bears his name[8]

In 1834,Dupuytren showed that the majority of the distal radial injuries in doubt were actually fractures ,which were found to be displaced dorsally. [9]

In 1838,Barton defined the transected type of fracture due to acting force when the hand is at volar flexion, with the line of the fracture passes obliquely intraarticularly and the coronal split of the fractured fragment. [10]

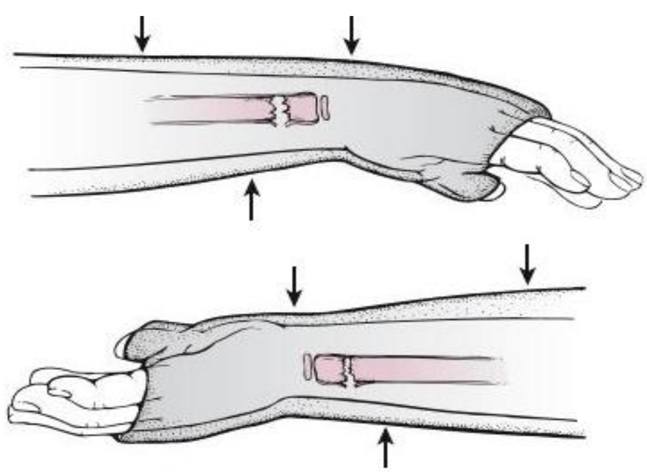
In 1847,Smith defined fracture with anterior displacement, as a result of falling with the hand in volar flexion that was named after him and hence the volar displacement. [11]

In 1915,Jones enumerated closed manipulation technique for reduction by increasing the deformity, giving traction and immobilizing in reduced position. [12]

In 1995,Connolly reduced the fractures by reversing the original mechanism of injury. [13]

In 1944,Anderson and O'Niel described the principles of ligamentotaxis for the use of external fixators in distal radius fractures. The external fixator acts as a neutralization device and to maintain traction. [14]

In 1950,Charnley et al described ' three point' contact for cast immobilization. The three points were dorsally over the dorsal fragment ,volarly and dorsally over the forearm and volarly over the distal aspect of proximal fragment. [15]



In 1964,Lambotte proposed pinning of radial styloid for maintaining purchase in distal radius fractures. [16]

In 1965,Ellis devised a technique of open reduction and internal fixation with ' T ' shaped plate for unstable Smith's or volar Barton fracture and dislocation[17]

In 1993,Agee found that volar tilt is brought about by volar translation of the hand.[18]

In 1967,Frykman first described distal ulna fractures associated with distal radius fractures. He reported that fall on the outstretched hand with the wrist joint in 40° to 90° of extension produces dorsally displaced distal radius fracture. He established an eponymous classification system, which defines the fracture as intra-articular or extra-articular. It also describes the involvement of radiocarpal and distal radioulnar joints along with the presence or absence of ulnar styloid process fracture. (19)

In 1984,Melone proposed a classification by describing four components of the radiocarpal joint and five patterns in intra articular fractures. (20)

Sarmiento and associates recommended plaster immobilization in supination, if distal radioulnar joint was found to be involved. (21)

Kapandji proposed two pin intra focal pinning. This was utilized in DRUJ restoration and creation of pseudo joint in distal ulna. (22)

In 1987,Weber described the bending mechanism and its relation to the fracture pattern of the distal radius. He also stated that collapse of the fracture is unavoidable due to pull of flexor and extensor tendons. (23)

In 1989,John M. Rayhack proposed the technique of ulnar- radial wiring to immobilize the distal radio-ulnar joint supplementing the ligamentotaxis. (24)

In 1989,John K.Bradway retrospectively reviewed results in 16 patients treated by open reduction and internal fixation and concluded that internal fixation is the treatment of choice for displaced, comminuted intra articular fractures. (25)

In 1990,Bartosh and Saldana stated that the technique of closed traction and reduction will not accurately restore palmar tilt due to thick palmar ligaments as compared to dorsal ligaments. (26)

In 1990,James Shaw et alconducted a biomechanical study and opined primary repair of displaced ulnar styloid avulsion fractures is essential for a stable distal radio ulnar joint. (27)

In 1993,Metz and Gilula stated that, all distal radius fractures should undergo postero-anterior and lateral view radiographs. (28)

In 1996,Rikkli described the three column concept of the wrist. He stated that the ulnar column serves as an axis of rotation for forearm and important load transmitter next to the middle column. (29)

In 1997,Louis W. Catalano III did a retrospective study to determine the long term functional and radiographic outcomes in a series of young adults treated with open reduction and internal fixation and concluded that outcome of a distal radial fracture is largely determined by its type. (30)

In 1997,Fitoussi F in a study of 34 patients with intra-articular fractures of the distal radius treated with open reduction and internal fixation with buttress plate and screws, concluded that the potential for restoration of normal alignment and stability of fixation are the main advantages of internal fixation with plates. (31)

In 1998,Carter PR evaluated a new method of internal fixation of unstable distal radius fractures using an anatomically pre shaped, rigid dorsal low profile plate with recessed screw holes along with autologous bone graft and concluded that patients with unstable fractures benefitted with the new plate. (32)

In 2000,Jakob M conducted a study on 76 patients and recommended a double plating method with 2 mm titanium plates, for dorsally displaced fractures, where open reduction is indicated to restore congruency and extraarticular anatomy. It is reliable in providing stable internal fixation and allowing early function. (33)

In 2004, Louis W.Catalano assessed the articular displacements of distal radius fractures and stated that current operative indications include fractures with radiocarpal or distal radioulnar joint step or gap deformities greater than l-2mm, gross distal radioulnar joint instability or those with extensive metaphyseal comminution. In general, there is tendency to consider operative fixation in younger, more active patients. (34)

Ring D et al stated condylar blade plate fixation of unstable distal ulna fractures associated with distal radius fractures gave good alignment and satisfactory results. (35)

In 2005,Nana AD et algave guidelines for acceptable reduction with parameters including radial inclination, radial height, palmar tilt and articular incongruity. (36)

In 2006, Schnall Stephen B et alevaluated the advantages of newer method of internal fixation with fracture specific implants and stated that they provided stable fixation with good functional outcome. (37)

In 2007, Rohit Arora et al analyzed internal fixation with 2.4 mm locking compression plate and claimed superior stability with maximum number of screws in metaphyseal segment. (38)

In 2007, Dennison DG Open reduction and internal locked plate fixation of distal radius fracture gave good to excellent functional outcome score. (39)

In 2015,S Kumaravel and N.Karthikeyen Distal radius fracture operated with external fixator with ligamentotaxis was found to give better results than closed reduction and cast immobilization. (40)

MECHANISM OF INJURY

Distal radius fractures are usually as a result of fall on an outstretched hand. There are multiple factors that determine the pattern of the fracture that include

1) Velocity

2) Position of hand and wrist at impact

3) Degree of rotation of forearm

4) Bone quality and density

When an individual falls forward fall on pronated forearm with the hand and wrist in extension, bending of the metaphyseal bone because the weight of the body is transmitted along the long axis of the radius. Also the hard diaphyseal bone causes impaction of cancellous metaphyseal bone that result in metaphyseal collapse. During the fall, compressive forces over the dorsal cortex and tensile stress acting over the volar cortex result in volar and dorsal cortical bone disruption. When there is a supination of distal end of radius with respect of the radial diaphysis, a dorsal displacement fracture occurs. In about fifty to sixty percent of distal radius fractures, associated ulnar styloid fractures. Also ulnar styloid fractures may be associated with triangular fibrocartilage disruption which may sometimes be an isolated finding.

Three main theories have been developed;

• The theory of compression impaction

• The avulsion theory

• The incurvation theory.

The Theory of Compression Impaction:

When the wrist is in extension the carpal bones are in contact with the surface of the impact. At the same time, the radial head is in compression against the humerus. This force is then automatically transmitted to the distal end of the radius. It is at this moment that the fracture occurs.

It is therefore a mechanism of compression impaction and crush; the wrist is an anvil on which the radius is crushed. This theory is based on the very important fact that all distal radial fractures are compression fractures and the fall occurs on a wrist in extension-pronation. Tensile forces act on the anterior part and compression forces on the posterior part. The posterior constraint forces are very high.

The Avulsion theory: The indirect forces presented by the body weight are transmitted through the humerus, the ulna, the interosseous membrane, the distal radius and then the volar wrist ligaments to the point of impact of the hand. The distal radial fracture is then caused by an avulsion mechanism applied by the tensile forces transmitted by the volar wrist ligaments.

The Incurvation theory: This theory stated that fractures are produced by bending forces. The fracture line is affected by three factors.

• The position of the hand;

• The extent of the area of impact;

• The magnitude of the applied force.

If tension increases at the level of the ulnar collateral ligament when the radial fracture occurs, an ulnar styloid process fracture will occur at the same time.The skin is usually not lacerated at the palm, implying that the hand has not slipped but was blocked on the floor. The body continues to go forward, moved by kinetic energy or inertia, and the volar wrist ligaments become tense because the wrist is placed in a hyperextended position[41].

If these ligaments resist, the forces are transmitted to the radiocarpal joint and the radius is in compression against the articular facets of the bones of the first carpal row. If the scaphoid and lunate are not crushed, the forces end at the level of the radius to produce a fracture at the weakest part of this bone. The dorsomedial fragment that separates due to this impact is called the ‘die punch’ fragment[42].

KINEMATICS

The muscles of the wrist are attached to the metacarpals.

Capitate act as the centre of rotation for wrist joint.

Wrist flexion and extension occur equally through radio carpal and midcarpal joints.Radial and ulnar deviations occur 60% through Mid-carpal joint and remaining through radio carpal joint.

Normal range of movements:

i. Flexion 0 to 70-90º

ii. Extension 0 to 70-90º

iii. Supination 0 to 70-90º

iv. Pronation 0 to 70-90º

v. Radial deviation 0 to 15-25º

vi. Ulnar deviation 0 to 25-35º

RADIOGRAPHIC PARAMETERS

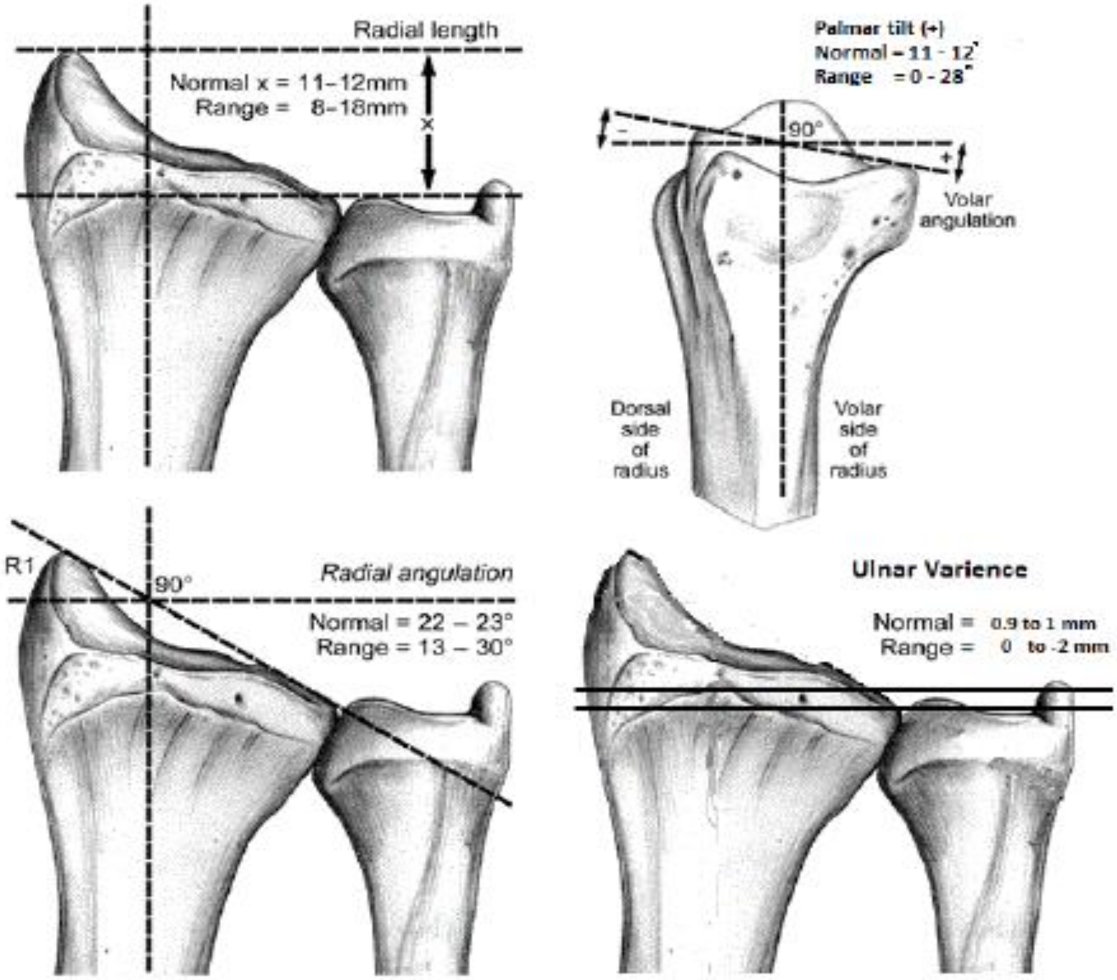


Fig:8 Radiographic Parameters

<u>Radial Height or Length</u>

It is distance between tip of radial styloid and articular surface of ulna along longitudinal radial axis in postero-anterior view.(Normal length is 11-12mm.)

Radial Inclination

Angle between longitudinal radial axis and a line touching tip of radial styloid and radial articular surface, measured in postero-anterior view.(Normal angle is 22-23˚.)

Palmar Tilt

Measured in lateral view it's angle between plane perpendicular to longitudinal radial axis and plane of distal articular surface.(Normal angle is 11-12˚.)

Ulnar Variance

It's difference between radial and ulnar articular sufaces with carpals.

It's measured in postero-anterior view. It may be positive, negative or neutral.

Positive value indicates loss of radial height.(Normal value is 0.9 to 1mm.)(Fig:8)

CLASSIFICATION

Various classifications had been described in the literature for the distal radius fractures.

Fernandez Classification

Fernandez proposed a mechanism-based classification system that would address the potential for ligamentous injury and there by assist in treatment recommendations .(Fig:9)

Type I: Metaphyseal ***bending*** fractures with the inherent problems of loss of palmar tilt and radial shortening relative to the ulna (DRUJ injuries).

Type II: ***Shearin****g* fractures requiring reduction and often buttressing of the articular segment.

Type III: ***Compression*** *of the articular surface* without the characteristic fragmentation; also includes the potential for significant interosseous ligament injury.

Type IV: ***Avulsion*** fractures or radio-carpal fracture dislocations.

Type V: ***Combined*** injuries with significant soft tissue involvement due to the high-energy nature of these fractures.

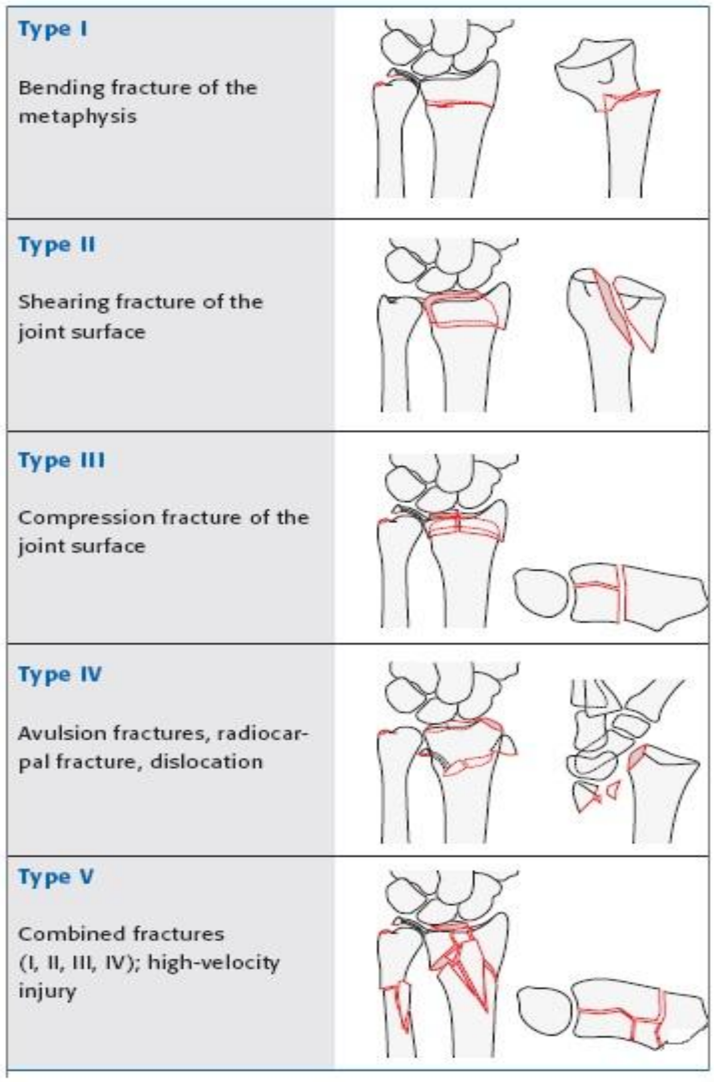


Fig:9 FERNANDEZ CLASSIFICATION OF DISTAL RADIUS FRACTURE

This systems also addresses **DRUJ** instabilty

Type I : **Stable** following reduction and DRUJ is congruent and stable

A) Avulsion fracture of styloid tip

B) Stable ulnar neck fracture

Type II : **Unstable** , following reduction subluxation or dislocation of ulnar head occurs

A)Substance tear of TFCC and/or palmar and dorsal capsular ligaments

B) Avulsion fracture base of ulnar styloid

Type III : Potentially unstable, subluxation is possible

A) Intraarticular # of sigmoid notch

B) Intra articular fracture of ulnar head

A.O. (Arbeitsgemeinschaft für Osteosynthesefragen) Classification(Fig:10)

The A.O. classification system emphasizes

i. The increasing severity of the bony injury

ii. The displacement of the distal fragment

iii. Extent of articular involvement

iv. Associated distal ulna fracture

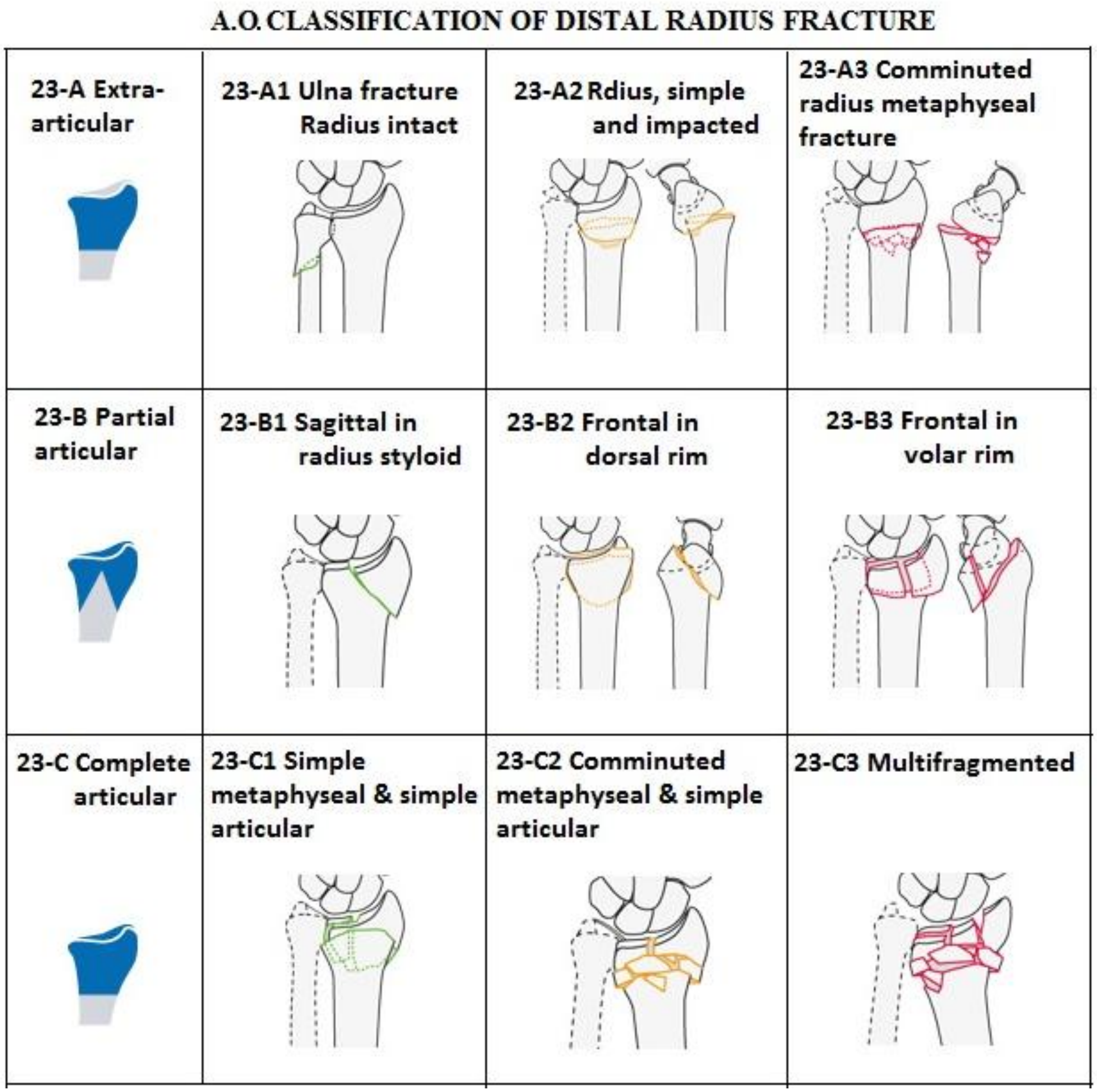


Fig:10 AO Classification

This classification system have three main categories .

Each of them further divided in subclasses

A. Extra-articular

B. Partial articular

C. Intra-articular

Type A – Extra articular fracture.

A1 – Extra articular ulnar fracture

A1.1 – Styloid process fracture

A1.2 – Simple fracture of metaphysis

A1.3 – Multifragmentary metaphyseal fracture

A2 – Simple or impacted extra articular radius fracture.

A2.1 – Undisplaced

A2.2 – With dorsal tilting

A2.3 – With anterior tilting

A3 – Simple or impacted multi fragment extra articular fracture.

A3.1 – With axial impaction and shortening

A3.2 – With a wedge

A3.3 – Complex

Type B – Partially articular fracture.

B1- Sagittal rim fracture

B1.1 – Simple lateral

B1.2 – Multifragmentary lateral

B1.3 – Medial

B2 – Dorsal rim fracture.

B2.1 – Simple

B2.2 – With an additional lateral sagittal fracture.

B2.3 – With dorsal dislocation of the carpus.

B3 – Volar rim fracture.

B3.1 – Simple with a small fragment

B3.2 – Simple with a large fragment

B3.3 – Multi fragmentary

Type C – Intra articular fracture.

C1 – Simple articular, simple metaphyseal fracture

C1.1 – With a postero medial articular fragment

C1.2 – Articular fracture line in sagittal plane

C1.3 - Articular fracture line in frontal plane.

C2 – Simple articular, multi fragment metaphyseal fracture.

C2.1 - Articular fracture line in sagittal plane.

C2.2 - Articular fracture line in frontal plane.

C2.3 – Metaphyseal fracture extends into the diaphysis

C3 – Complete articular multi fragment metaphyseal fractures.

C3.1- Metaphyseal simple

C3.2 – Metaphyseal fracture also multi fragmentary

C3.3 – Multi fragmentary metaphyseal fracture extending into the diaphysis.

The complete AO classification for distal radius fracture have poor inter observer reliability and the main group classes are sufficient to be used reliably to grade the severity of the fracture.

Frykman classification(Fig:11) concentrated on articular and ulnar (styloid or shaft)involvement. He specifically differentiated involvement of radiocarpal and distal radioulnar joint, as intra-articular involvement and ulnar involvement were the most prognostic factors.

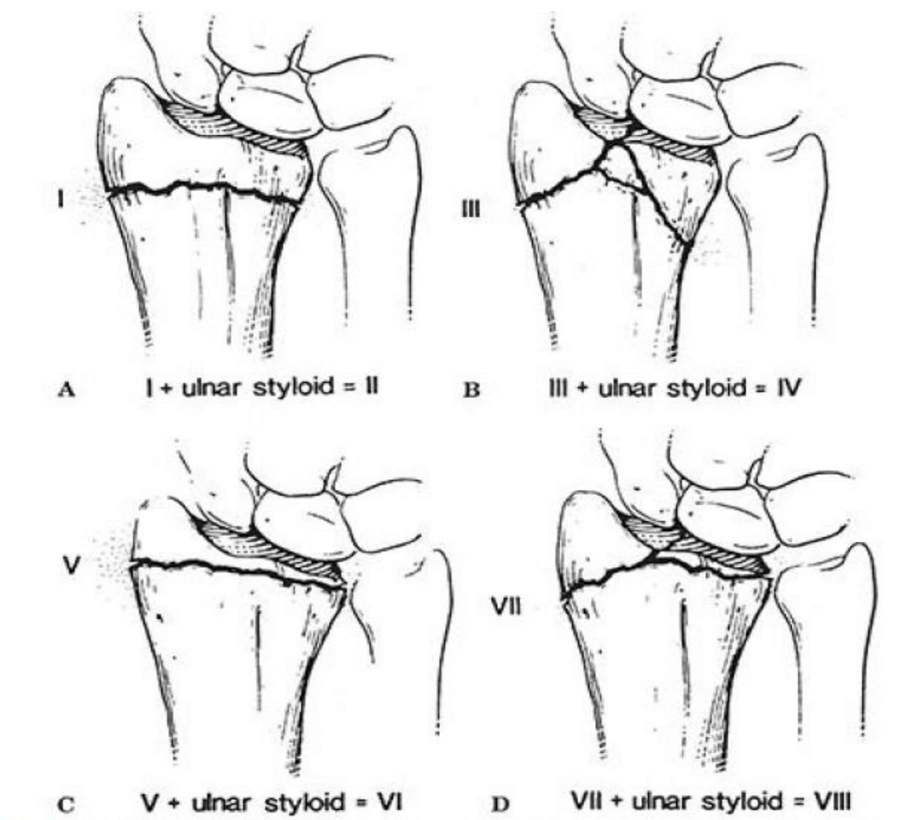


Fig:11 Frykman classification

FRYKMAN CLASSIFICATION	Ulnar styloid fracture	Ulnar styloid fracture
	ABSENT	PRESENT
EXTRA ARTICULAR	I	II
INTRA ARTICULAR		
RADIO CARPAL JOINT	III	IV
RADIO ULNAR JOINT	V	VI
RADIO CARPAL AND RADIO ULNAR JOINT	VII	VIII

MELONE classified intra-articular fractures considering that each fracture consisted

of four parts:(Fig:12)

i) Radial styloid,

ii) Dorsal medial fragment,

iii) Volar medial fragment, and

iv) Radial shaft.

The medial complex is the two medial fragments, which make up the lunate fossa and based his classification on the medial complex position.

Type 1—The medial complex is not displaced or minimally displaced as a unit without any comminution. Closed reduction yields stable result.

Type 2—The medial complex is moderately or severely displaced as a unit with Cortical comminution on volar and dorsal aspect. “Die punch” and unstable

A—Irreducible , closed.

B—Irreducible, closed because of impaction.

Type 3—As type 2 but with a spike of the radius on volar side, which may compromise the median nerve.

Type 4—Split fracture and unstable. The medial complex fragments are severely comminuted with rotation of fragments.

Type 5 —Explosion injury. Severe displacement and comminution often associated with diaphyseal comminution.

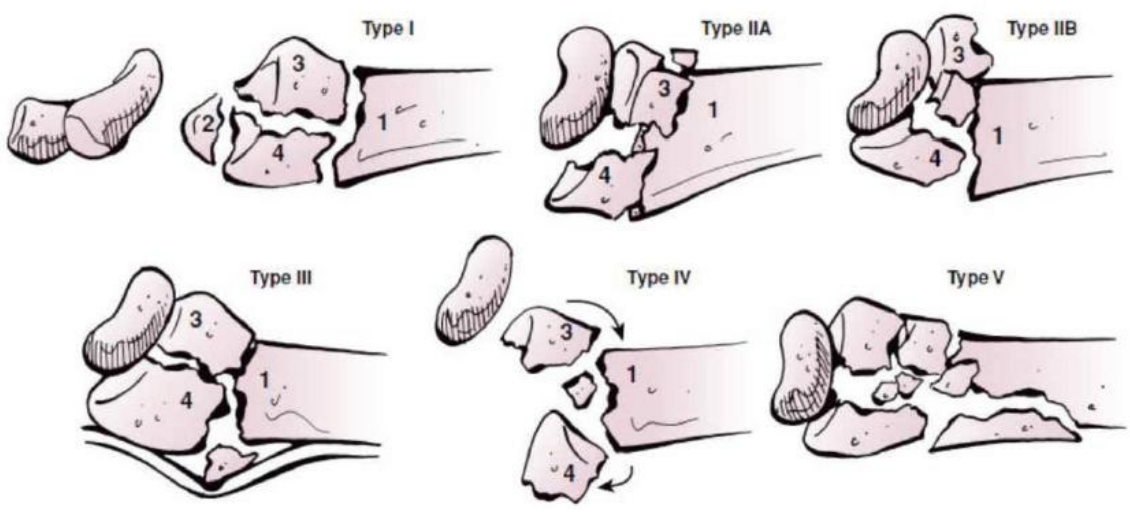


Fig:12.Melone’s Classification

Radiographic evaluation

In a suspected case of distal radius fracture standard postero-anterior and lateral view radiographs are taken.

In the postero-anterior view radiograph , following parameters are given importance

1. Loss of radial height
2. Radial inclination
3. Ulnar variance
4. Intra-articular step-off
5. Fracture comminution
6. Associated ulnar styloid fracture
7. Distal radio-ulnar joint injury

Following parameters attended in lateral view radiograph

1. Palmar tilt
2. Metaphyseal comminution
3. Volar cortex displacement

An oblique view may be obtained to assess the extent of comminution.

Contra lateral wrist postero-anterior and lateral view radiographs are taken to assess the patients normal radiological parameters.

Computed Tomography:

CT scans have joined the armamentorium of investigations in distal radius fractures. They provide the best assessment of articular surface depression, comminution and displacement. In few cases with suspicion of severe comminution and displacement, CT of wrist was done for pre-operative planning.

Radiographic criteria for acceptable reduction[41]

1. Ulnar variance – No more than 2mm of shortening relative to ulnar head
2. Radial height – Within 2-3 mm of normal wrist
3. Radial tilt – Neutral
4. Radial inclination - No less than 10 degrees
5. Intra articular step off – Less than 2mm

METHODS OF TREATMENT

There are various methods for treating an adult with distal radius fracture

a) Conservative management

b) Surgical treatment

i. Percutaneous pinning

ii . Spanning external fixation

ii i. Non- spanning external fixation

iv . Open reduction and dorsal plating

v . Open reduction and volar plating

v i. Open reduction and fixation with locking compression plate

vi i. MIPO

vi ii. Open reduction and fragment specific fixation for comminuted fracture

ix. Distraction plating

COMPLICATIONS: The reported complication rates of distal radius fracture in the literature vary from 6% to 80%. Complication may occur from the fracture or its treatment.

Immediate complications:

1) Nerve injuries - commonly Median nerve.

2) Acute Carpal Tunnel Syndrome.

3) Compartment syndrome.

4) Open fractures

5) Skin injury during manipulation in the elderly.

6) Missed associated injuries.

Early complications (less than six weeks):

1) Loss of reduction

2) Plaster related complications

3) Infection in open fractures and operated cases.

4) Carpal Tunnel Syndrome.

5) Tendon rupture.

Late complications (more than six weeks):

1) Carpal Tunnel Syndrome.

2) Reflex Sympathetic Dystrophy

3) Malunion

4) Delayed union

5) Post traumatic arthritis

6) Tendon rupture and adhesions.

7) Dupuytren’s contracture

Complications related to External Fixation:

1) Pin site infection

2) Pin loosening

3) Radial sensory nerve injury

4) Over distraction which may lead to stiffness, Pain and iatrogenic nonunion.

AIM OF THE STUDY

To evaluate the functional recovery and radiological outcome of Closed intra articular fracture of distal radius in adults treated by various fixation devices like Volar plate ,External fixation augmented with or without K- wire and K- wire with plaster immobilization.

MATERIALS AND METHODS

It is a prospective study conducted in Thanjavur Medical college and Hospital from July 2017 to September 2019 after ethical committee clearance(enclosed). Skeletally mature adult patients with acute closed intra articular fracture of distal radius were chosen treated with various common fixation and the outcome analysis done.The method of patient selection details were shown in the flow chart.

INCLUSION CRITERIA

1) Closed acute **intra articular** fractures of distal radius in skeletally mature adults with or without joint subluxation.

EXCLUSION CRITERIA

1) Open Fractures of distal radius, associated fractures of the shaft of radius

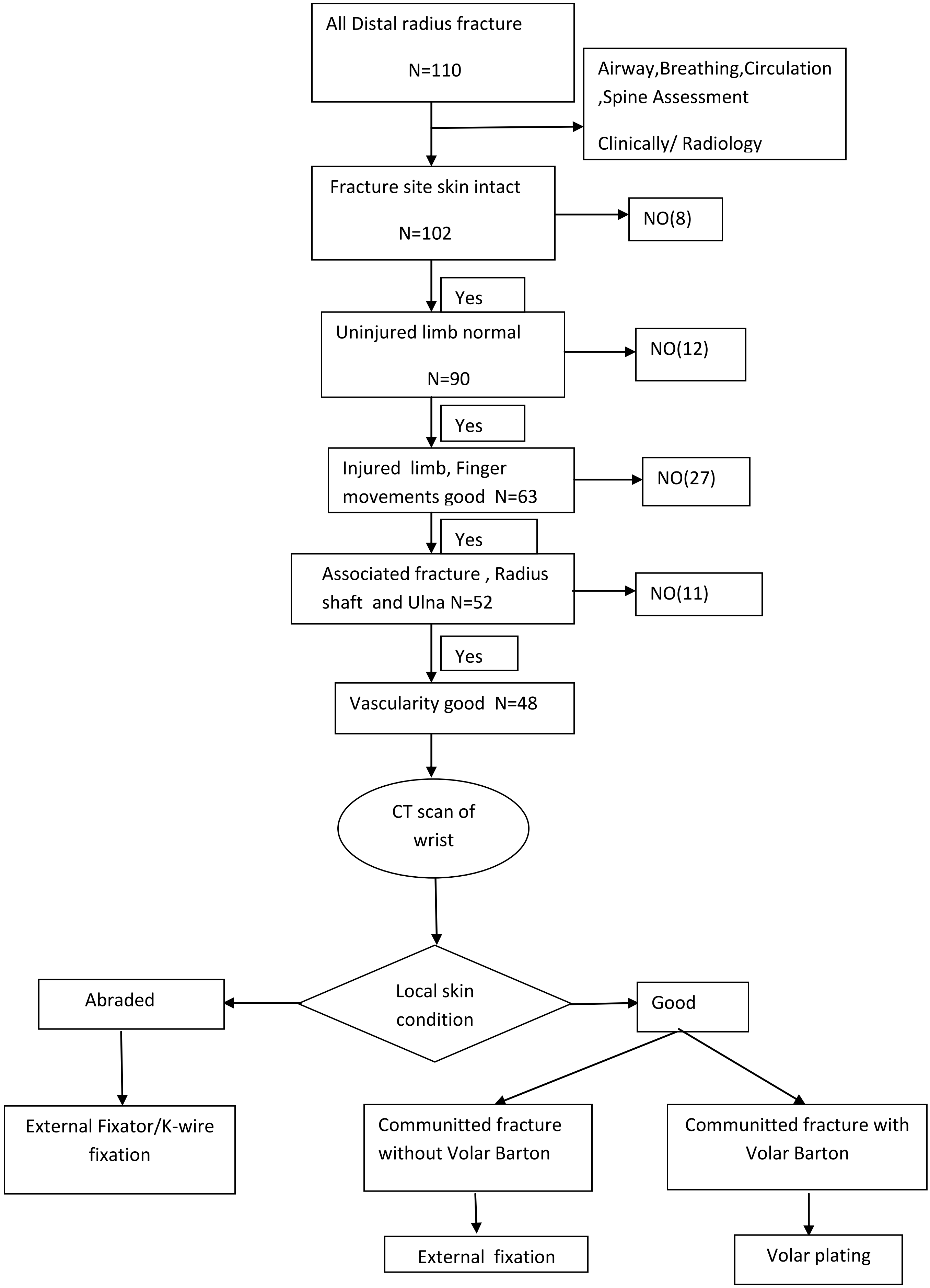
2)Distal radius fractures in skeletally immature patients and patient presented late

3)Severe co-morbidities.

4)Bilateral Distal radius fracture(No comparison)

5)Old malunited fracture(Will affect scoring)

Flow chart


All Distal radius fracture
N=110
Airway,Breathing,Circulation ,Spine Assessment
Clinically/ Radiology
Fracture site skin intact
N=102
NO(8)
Yes
Uninjured limb normal
N=90
NO(12)
Yes
Injured limb, Finger movements good N=63
NO(27)
Yes
Associated fracture , Radius shaft and Ulna N=52
NO(11)
Yes
Vascularity good N=48
CT scan of wrist
Local skin condition
Abraded
Good
External Fixator/K-wire fixation
Communitted fracture without Volar Barton
Communitted fracture with Volar Barton
External fixation
Volar plating

PRE OPERATIVE ASSESSMENT OF PATIENT

1) Pre-operative – Blood Haemoglobin,
2) Blood Sugar,
3) Blood Urea,
4) Serum Creatinine,
5) ECG,
6) Radiograph of chest

On presentation, the following were evaluated.

1) Condition of skin
2) Condition of local nerve function
3) Condition of vascularity
4) Tendon function
5) Shoulder,elbow and finger movements
6) General medical condition.
7) Systemic injury ,head injury and associated fractures
8) Radiograph of the involved region ,
9) CT-Scan of distal radius.

In pre operative posterio anterior and lateral view radiographs of the affected distal radius ,the following observations were made.

1) Radial length

2) Dorsal angulation

3) Radial inclination

4) Ulnar variance

5) Dorsal comminution

6) Step

7) Gap

CT Scan of distal radius was done for all patients to assess the fracture pattern

All procedures were done under suitable anesthesia (Regional/General anesthesia)(Fig 13). Through appropriate approach(Anterior,Posterior or Lateral) fracture site exposed and pattern assessed and fracture reduced and appropriate fixation done under C Arm guidance.

Fig:13 .Regional Anaesthesia(Left Supra clavicular block)

Post operative protocol include analgesics and antibiotics and early mobilization Patient will be reviewed in 4^{th} ,8^{th},and 12^{th} week after surgery.Patient will be assessed for the functional recovery using Gartland and Werley premodified score and anatomic evaluation by Lindstrom and Frykman grading.

VOLAR PLATING

After painting with Betadine ® and draping, wrist was placed supine and neutral on a roll of towel on side table .In our study we used modified Henry approach, it uses the plane between the flexor carpi radialis tendon and the radial artery. Skin incision is made on the radial side of the flexor carpi radialis tendon .Ulnar or radial curve is done so not cross the flexion crease perpendicularly

Fig:14.Modified Henry's approach

Sheath of the tendon is opened and retracted towards ulnar ,incision is deepened between flexor pollicis longus and radial artery. Finger is used to sweep the flexor pollicis longus muscle belly towards the ulna.Pronator quadratus muscle is exposed and elevated using L shaped incision on the radial border . Care should be taken not to injure the sensory branch of median nerve and radial artery.

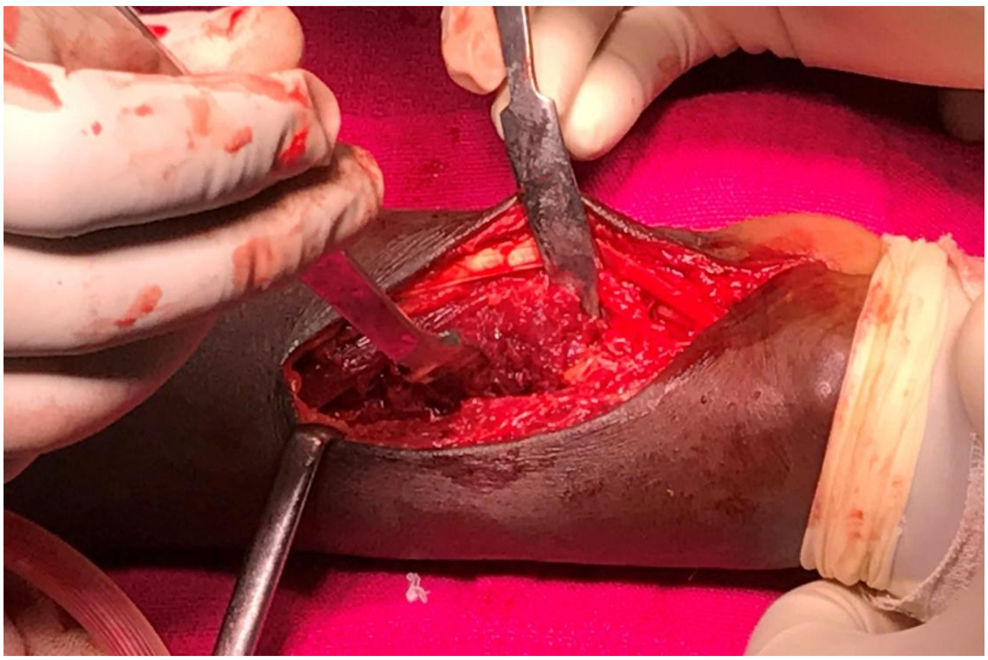


Fig:15 . 'L shaped' cut made to reflect Pronator Quadratus to expose the fracture

Distal radius is exposed along with its fracture fragments. The fracture was then reduced by direct visualization of the fragments. The central lunate fragment which plays a key role in load transmission if found depressed should be elevated with a small osteotome .After reducing the fracture fragments , volar plate was placed on the volar surface of distal radius and after correcting its placement just proximal to the imaginary watershed line (2mm from the radicarpal joint surface) and fixed initially with K- wire under C-Arm guidance. True AP, lateral views were taken and any fine adjustments if needed can possibly be done on the plate.

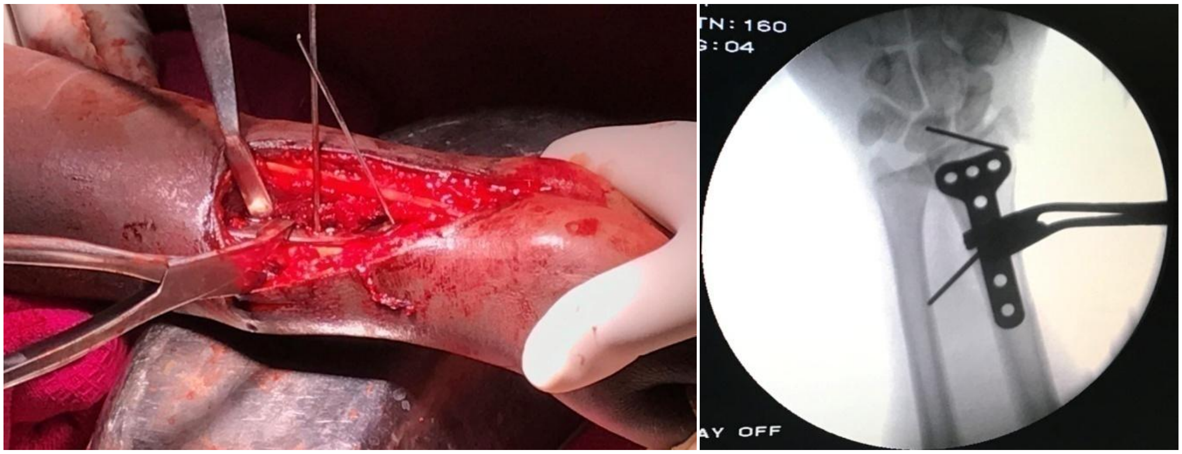


Fig:16 .Fracture provisionally fixed with K wire

Screws were aimed to be placed 2mm below joint line and should not penetrate into the articular area. The distal screws were put which should be 2mm short from the dorsal cortex so that the screws would not irritate the extensor tendons. Finally AP, lateral and oblique views were taken to check the fracture reduction and distal screw penetration. After achieving   hemostasis, wound closed in layers.Pronator quadrates is allowed to fall over the plate, if possible reattached to its radial attachment to prevent tendon irritation. Skin is closed and sterile bandage applied.

Fig:17.Surgical wound after volar locking plate fixation

POST OPERATIVE CARE AND REHABILITATION:

Patients were encouraged limb elevation and active finger mobilization exercises in immediate post operative period. Distal neurovascularity was assessed regularly and intravenous antibiotics were given for 3 days and after that changed to oral antibiotics till suture removal. Post operatively the wrist was immobilized in a short arm plaster for 10-12 days and six pack exercises were started(Fig 18) . Suture removal was done for all the cases on 12^{th} day.

After suture removal the slab was removed and gentle active wrist mobilization exercises were started. Resisted exercises were started about 6 weeks after surgery. Patients were recommended for follow up at 4 weeks,8 weeks and 12 weeks 3 months, 6 months and 12 months interval and routine radiographs were taken to assess the fracture healing.

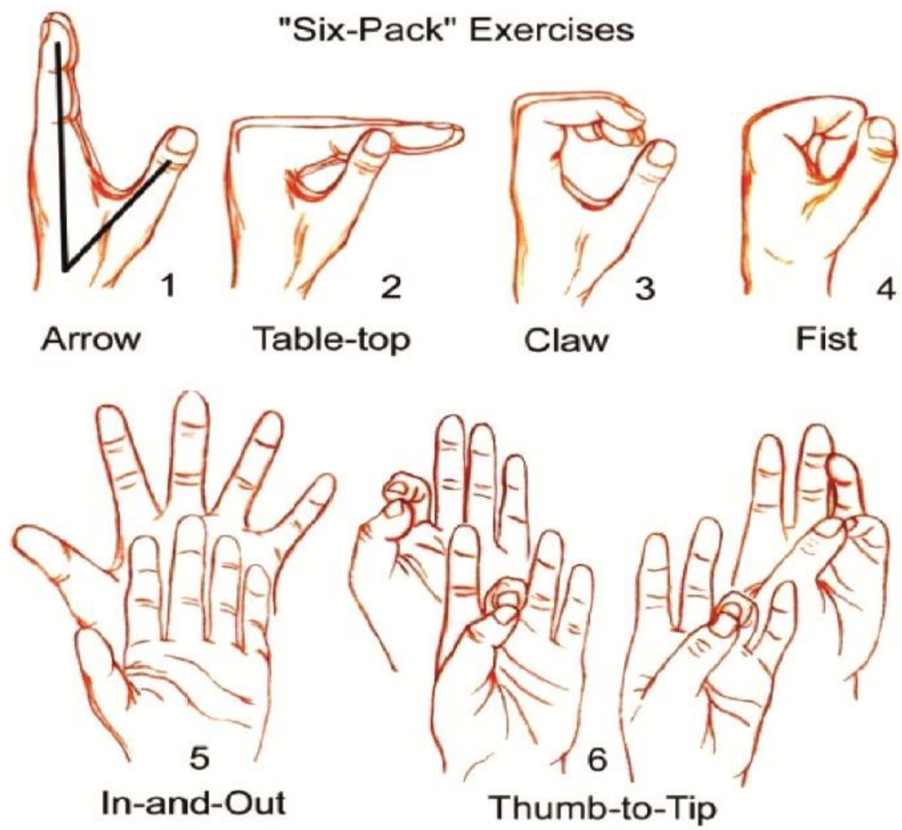


Fig:18.Six pack exercises (*Dobyns and Linscheid)*

PERCUTANEOUS K WIRE FIXATION:

In cases which had a displaced radial styloid or fragments too small for other means of fixation, was fixed with Kirschner wires augmented with external fixator The affected limb painted and draped. The fracture reduction done with same manoeuvre as closed reduction group. . Intrafocal leverage using K- wire under C- arm guidance was done and fragments alignments were checked .After satisfactory reduction percutaneous K-wire fixation done.

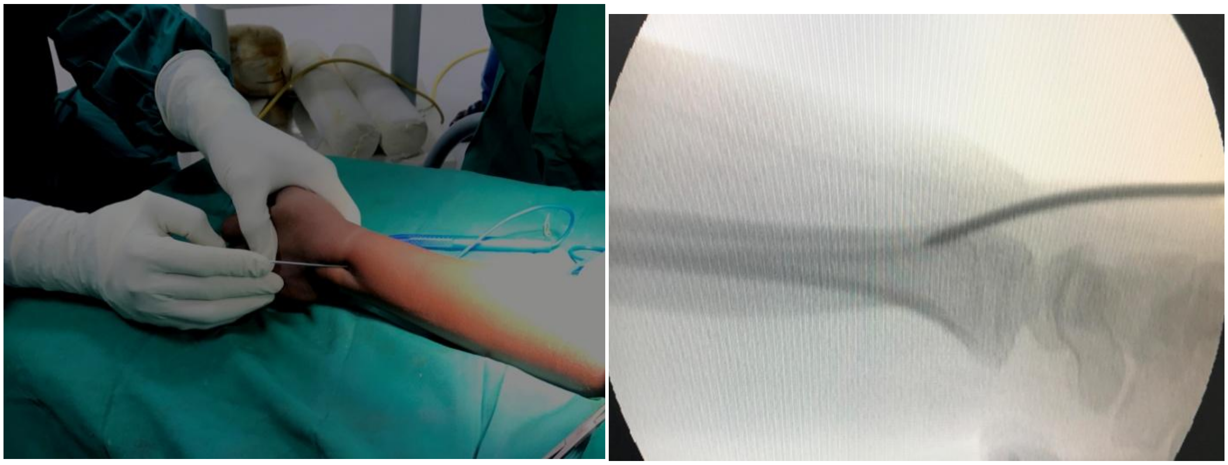


Fig :19. Intrafocal leverage of dorsally tilted fracture fragments

K wires of thickness 1.5mm and 1.8 mm were used. Two are introduced from the tip of the radial styloid towards medial cortex of distal radius, one from the dorsoulnar aspect of dorsal distal radius in dorso-volar direction. First, a 5 mm incision is made over the tip of the radial styloid. The radial styloid is exposed by blunt dissection and great care is taken not to injure the sensory branch of the radial nerve or the tendons of the first and third extensor compartments.The K wire tip is introduced between the soft tissues. After checking reduction and anticipated direction of the K-wire using image intensification,

The 1st K-wire is introduced carefully with a power drill. The drill K wire is stopped after just penetrated the medial cortex of the radial shaft.

The 2nd K-wire is introduced through the radial styloid in the same manner, but in a divergent direction.

The 3rd K-wire is introduced from the dorsoulnar rim of the radius into the anterior cortex of the radial shaft.

The K-wires were cut and bent 180º to avoid further migration into the bone. To prevent skin penetration by bent K- wire tips, small gauze piece soaked with betadine was applied at base of K- wire entry point. The forearm was splinted with dorsal below-elbow plaster slab, arm cuff and collar sling provided for forearm support.

POST OPERATIVE CARE AND REHABILITATION:

Postoperatively limb elevation was given to prevent oedema development. Intravenous antibiotics were given for two days followed by oral antibiotics for three more days. Patients were encouraged for active finger movements with special emphasis on ‘Six-Pack’ exercise regime(Fig:18).Elbow and shoulder movements also taught. Patients were discharged at 3-4 days post-op and reviewed after 1 week. At 1st visit any sign of pin site infection was noted. Plaster slab was maintained. Patients were reviewed after this at 3rd week of postop .At 3rd week any plaster slab loosening noted, standard postero-anterior and lateral radiographs taken to assure K- wire position and maintenance of fracture reduction. At 6th post-op week cast removal and K- wire removal done after fracture union was confirmed radiologicaly . At the end of 6 weeks elastocrepe bandage was applied for further 1 week. At this stage active wrist exercise, forearm rotational exercises also taught .After this patients were reviewed at 8th week , 12th week ,6th month and 12th month . At each visit radiological and functional assessment done and compared with normal limb.

EXTERNAL FIXATION WITH OR WITHOUT " K" WIRE

The affected limb was painted and draped. The metacarpal pins were applied first. 1cm incision made over metaphyseal flare of second metacarpal. Blunt dissection was carried out avoiding injury of superficial radial nerve and first dorsal interosseous muscle. Second metacarpal was drilled with 2.0mm drill bit while protecting soft tissues using drill guide. Then 2.5mm × 100mm Schanz pin inserted. A second pin was applied distally by same method. Pins on the radius were applied 10cm proximal to radial styloid.1 cm incision was made along the line joining lateral condyle Humerus and Lister's tubercle of distal Radius, blunt dissection carried out to reach radial shaft avoiding injury to radial sensory nerve and extensor tendons. Radial shaft was drilled with 2.5mm drill bit while protecting soft tissues with drill guide. Drilling was done in such a way that pins were placed on radial side and 30º dorsally. A 3.5mm × 100mm Schanz pin was inserted. Second radial pin was applied distal to first pin by same method.The metacarpal pins were connected to multiaxial ball clamp and radial pins were connected to another multiaxial ball clamp. The ball clamps were connected to distraction rod. Radiographs were taken and fine tuning of distraction done. No more than 2 - 3mm distraction was applied over radio carpal joint.

Postoperatively patients were encouraged to do active finger movements from day one. Six pack exercises were taught.

Limb was kept elevated for 24 – 48 hours. Parental antibiotics were given for two days followed by oral antibiotics for one more week. Pin sites were regularly inspected and Betadine dressings given. Patients were discharged by fifth day and reviewed every week till six weeks. On every visit, extent of finger movements was noted. Pin site was examined for infection.At six weeks after confirming union, external fixator was removed and sterile dressing and elastocrepe bandage applied. A radiograph was also taken. Active wrist mobilization was started. Patients were reviewed on three months, six months and one year of treatment. Every time functional and radiological assessment were made and compared to the normal side.

OBSERVATIONS AND RESULTS

Forty eight patients were enrolled in our study. Of them twenty six were males and twenty two were females.. The age group from 20 to 50 years were taken in our study with mean age of 39.13 years .

AGE GROUP

Table 1.1- Frequency distribution of age group .

s.no	Age group in years	Frequency	Percent
1	20-30	11	22.9%
2	31-40	15	31.3%
3	41-50	22	45.8%

In our study more number of patients were in 41 -50 age group

MODE OF INJURY

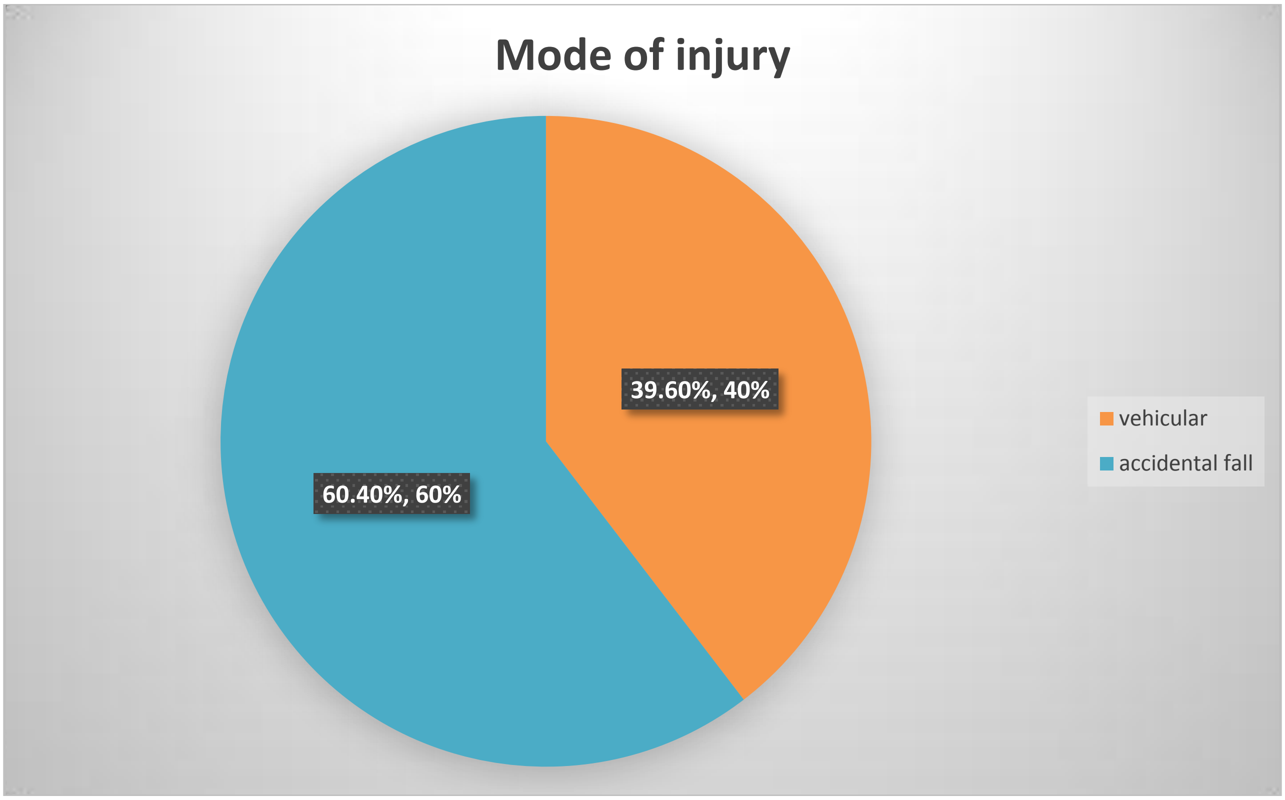


Fig 20:Frequency distribution of mode of injury

In our study , most of patients sustained an accidental fall around 60% .

Nineteen patients, about (40%) were injured in vehicular accidents.

SEX DISTRIBUTION

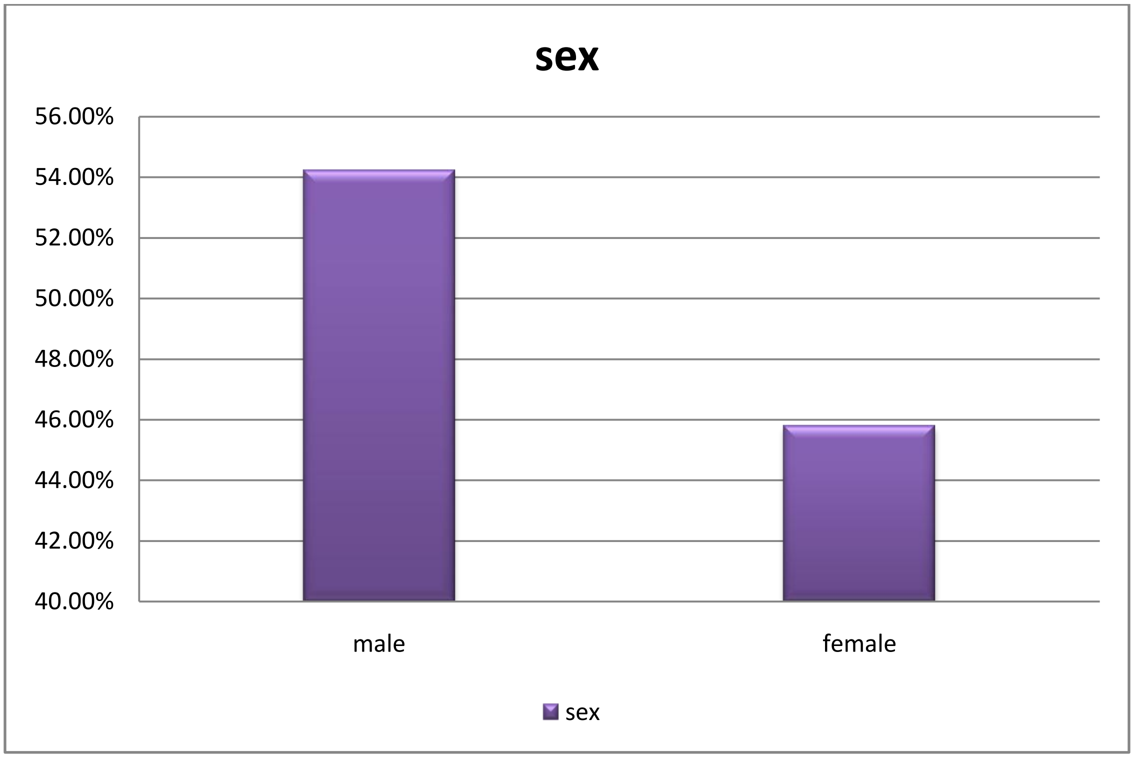


Figure 21:Frequency distribution of sex

Among the total study populations Sex distribution shows male predominance greater than 50%

SIDE OF INJURY

Table 1.2–Frequency distribution of side of injury

s.no	Side of injury	Frequency	Percent
1	Right	21	43.8%
2	Left	27	56.3%

In our study left side injury is greater the right side. The right side was involved in twenty one patients and left side was involved in twenty seven patients.

TYPE OF FRACTURE

Table 1.3 –Frequency distribution of AO type

S.no	**AO type**	**Frequency**	**Percent**
1	B1	6	12.5%
2	B2	8	16.7%
3	B3	13	27.1%
4	C1	6	12.5%
5	C2	8	16.7%
6	C3	7	14.6%

In our total study population twenty seven patients belong to AO Type B more commonly B3 subtype(27.1%) and twenty two patients belong to AO Type C most commonly C2 subtype(16.7%). The mean duration between injury and procedure was 4.8 days.

SURGICAL PROCEDURES

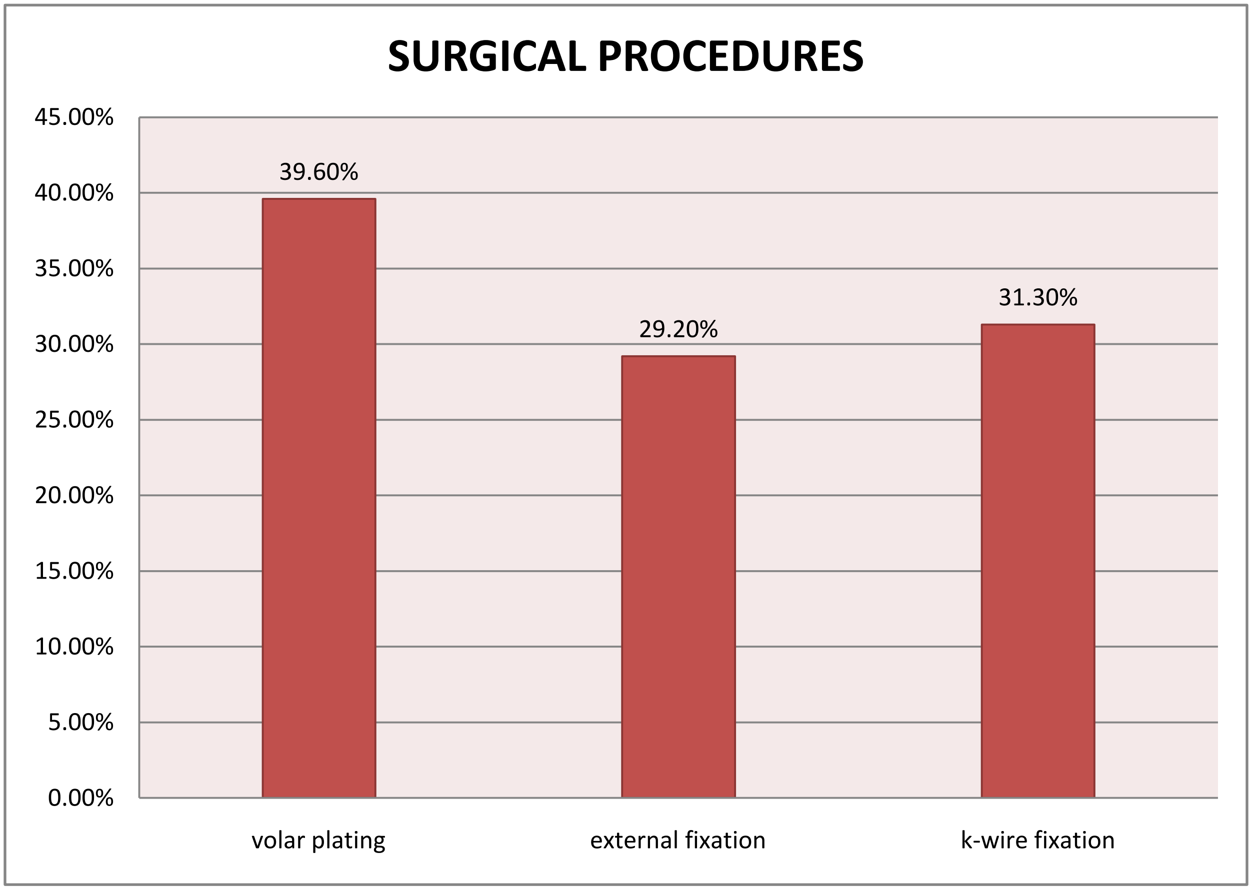


Fig 22:Frequency distribution of surgical procedures

Of the total study population.Nineteen patients were treated with volar plating and fourteen patients with external fixationand fifteen patients with K wire fixation.

SURGICAL COMPLICATION

Table 1.4 –Frequency distribution of surgical complication

S.no	Surgical complication	Frequency	Percent
1	Present	7	14.6%
2	Absent	41	85.4%

In our study about complications about 14.6 % developed surgical and its related complications. In external fixation patients, one patient developed pin site infection necessitating pin removal at five weeks.One patient developed radial sensory nerve deficit and another each patient developed finger stiffness and pin bending complications . In volar plating group one patient developed intra articular screw migration and keloid formation.In K-wire fixation groups ,two patient developed pin site infection.None of them developed metacarpal fracture, median nerve deficit or tendon problem.

Table 1.5 –Frequency distribution of pain

S.no	Pain	Frequency	Percent
1	Mild	11	22.9%
2	Moderate	6	12.5%

During the follow up, patients were evaluated for pain, working ability, grip strength and complications like stiffness, deformity,reflex sympathetic dystrophy, median nerve deficit and tendon rupture.In our study about 64.6% of patients has no pain at one year follow up.

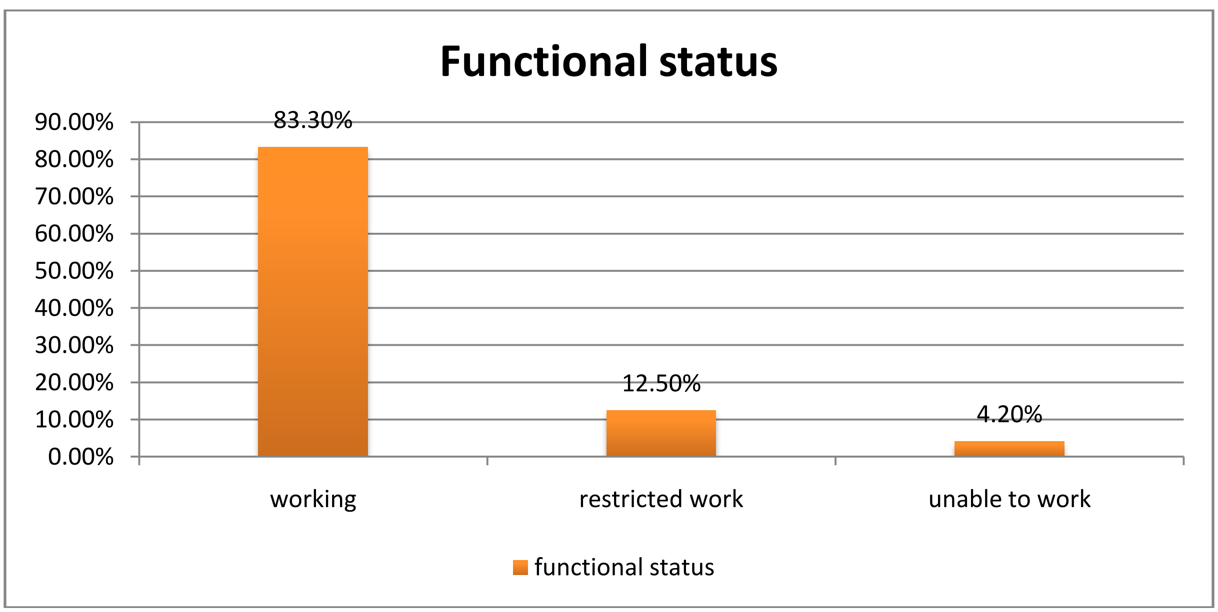


Fig23:Frequency distribution of functional status

In our study about 31(64.6%) were able to do their day to day activities without pain and 83.3% patients were working without any functional disability.

Table 1.6 –Frequency distribution of stiffness

S.no	Stiffness	Frequency	Percent
1	PRESENT	10	20.8%
2	ABSENT	38	79.2%

In our study about 79.2 % were able to work without any stiffness .

Inferential statistics

Chi-square test and Fisher exact test were used to compare the below following relations.In our study male sex shows predominance 54.16%.Age group 41-50 years (45.8%) were commonly involed.Left side injury(56.25%) is greater then right side injuryand mode of injury by accidental fall (60.41%) were more common than vehicular (39.58%).

Table 2.1 Relation between surgical procedures versus mode of injury

		N=48			
Sl.no	**variables**	**Volar plating(19)**	**External fixation(14)**	**K wire fixation(15)**	**P value**
1	**Sex**	Frequency percent	Frequency percent	Frequency percent	**0.590**
	Male (26)	12 (46.2%)	7 (26.9%)	7 (26.9%)	
	Female (22)	7 (31.8%)	7 (31.8%)	8 (36.4%)	
2	**Age group**				**0.446***
	20-30yrs(11)	6 (54.5%)	1 (9.1%)	4 (36.4%)	
	31-40yrs (15)	4 (26.7%)	6 (40.0%)	5 (33.3%)	
	41-50yrs (22)	9 (40.9%)	7 (31.8%)	6 (27.3%)	
3	**Side of injury**				**0.468**
	Right (21)	8 (38.1%)	8 (38.1%)	5 (23.8%)	
	Left(27)	11 (40.7%)	6 (22.2%)	10 (37%)	
4	**Mode of injury**				**0.666**
	Vehicular (19)	9 (47.4%)	5 (26.3%)	5 (26.3%)	
	Accidental fall(29)	10 (34.5%)	9 (31.0%)	10 (34.5%)	

***p value-done by Fisher exact test**

Most of the patients were operated within one to five days of admission with significant P value(0.02).Fracture AO Type B2,B3 were mostly fixed with K - wire fixationand AO Type C2,C3 were mostly fixed with volar plating.Complication rates were very minimal in volar plating (14.3%) and higher in external fixation patients(57%), followed by K wire fixation.

patients(28.6%).About 80 % of K wire fixation has no pain followed by 63.15% in volar plating and 50% in external fixation.

Table 2.2 Relation between surgical procedures versus duration to surgery

		N=48			
Sl. no	**Variables**	**Volar plating(19)**	**External fixation(14)**	**K wire fixation(15)**	**P value**
1	**DURATION TO SURGERY**	Frequency percent	Frequency percent	Frequency percent	0.02*
	1-5 days(36)	10 (27.8%)	12 (33.3%)	14 (38.9%)	
	6-10 days(12)	9 (75%)	2 (16.7%)	1 (8.3%)	
2	**AO type**				0.759*
	B1(6)	2 (33.3%)	1 (16.7%)	3 (50%)	
	B2 (8)	2 (25%)	4 (50%)	2 (25%)	
	B3 (13)	4 (30.8%)	4 (30.8%)	5 (38.5%)	
	C1 (6)	2 (33.3%)	1 (16.7%)	3 (50%)	
	C2 (8)	5 (62.5%)	2 (25%)	1 (12.5%)	
	C3 (7)	4 (57.1%)	2 (28.6%)	1 (14.3%)	
3	**COMPLICATION**				**0.197**
	Present(7)	1 (14.3%)	4 (57.1%)	2 (28.6%)	
	Absent(41)	18 (43.9%)	10 (24.4%)	13 (31.7%)	
4	**Pain**				**0.019**
	No pain (31)	12 (38.7%)	7 (22.6%)	12 (38.7%)	
	Mild pain (11)	2 (18.2%)	6 (54.5%)	3 (27.3%)	
	Moderate pain(6)	5 (90%)	1 (10%)	0	

***p value-done by Fisher exact test**

Table 2.3 Relation between surgical procedures versus functional status

		N=48			
Sl.no	**Variable**	**Volar plating(19)**	**External fixation(14)**	**K- wire fixation(15)**	**P value**
1	**Functional status**	Frequency percent	Frequency percent	Frequency percent	0.802*
	Working (40)	16 (40%)	12 (30%)	12 (30%)	
	Restricted (6)	3 (50%)	1 (16.7%)	2 (33.3%)	
	Unable to work(2)	0	1 (50%)	1 (50%)	
2	**Stiffness**				1.000*
	Present (10)	4 (40%)	3 (30%)	3 (30%)	
	Absent (38)	15 (39.5%)	11 (28.9%)	12 (31.6%)	

***p value-done by Fisher exact test**

About 85.7%(External fixatorandKwire) group , followed by 84.2% volar plating patients were working without any functional disability.All the patients were evaluated as per modified criteria suggested by Gartland and Werley for functional assessment. This system consists of subjective evaluation, objective evaluation and assessment of complication and accordingly demerit points were awarded. By this system, in volar plating patients patients (55.6%) had excellent results followed by 33.3% in external fixation and 11.1% in K wire fixation patients.In our study none of the patient has poor results.

TABLE 2.4 FUNCTIONAL GRADING

Gartland and Werley score	N = 48						
	Volar plating(19)		**External fixation(14)**		**K- wire fixation(15)**		**P value**
	Frequency	percent	Frequency	percent	Frequency	percent	**0.581***
Excellent (9)	5	(55.6%)	3	(33.3%)	1	(11.1%)	
Good(34)	12	(35.3%)	9	(26.5%)	13	(38.2%)	
Fair(5)	2	(40%)	2	(40%)	1	(20%)	

***p value-done by Fisher exact test**

Anatomic evaluation was done as per Lindstrom and Frykman criteria. In volar plating patients, (42.9%) belongs to grade 1 results (i.e. no deformity) followed by 34.3% in external fixationand22.9% in K wire fixation .None of the patients in our study had grade 4 results(i.e severe deformity)

TABLE 2.5 ANATOMICAl GRADING

Lindstrom andFrykman	N=48						
	Volar plating(19)		**External fixation(14)**		**K-wire fixation(15)**		**P value**
	Frequency	percent	Frequency	percent	Frequency	percent	0.212
No significant deformity (35)	15	(42.9%)	12	(34.3%)	8	(22.9%)	
Slight deformity(10)	3	(30%)	1	(10%)	6	(60%)	
Moderate deformity(3)	1	(33.3%)	1	(33.3%)	1	(33.3%)	

***p value-done by Fisher exact test**

Table 2.6 Relation between surgical procedures and Grip strength.

Grip strength	N=48						
	Volar plating(19)		**External fixation(14)**		**K- wire fixation(15)**		**P value**
	Frequency	percent	Frequency	percent	Frequency	percent	0.116
Fair	4	21.1%	0	0	3	20%	
good	5	26.3%	3	21.4%	7	46.7%	
Excellent	10	52.6%	11	78.6%	5	33.3%	

In our study at one year follow up finger grip strength was measured and compared with patients normal hand.About 78% of patients in external fixation has excellent grip strength followed by 52 % in volar plating patients.

CASE ILLUSTRATIONS

Case 1

Pre operative radiograph showing Anterio posterior and lateral views

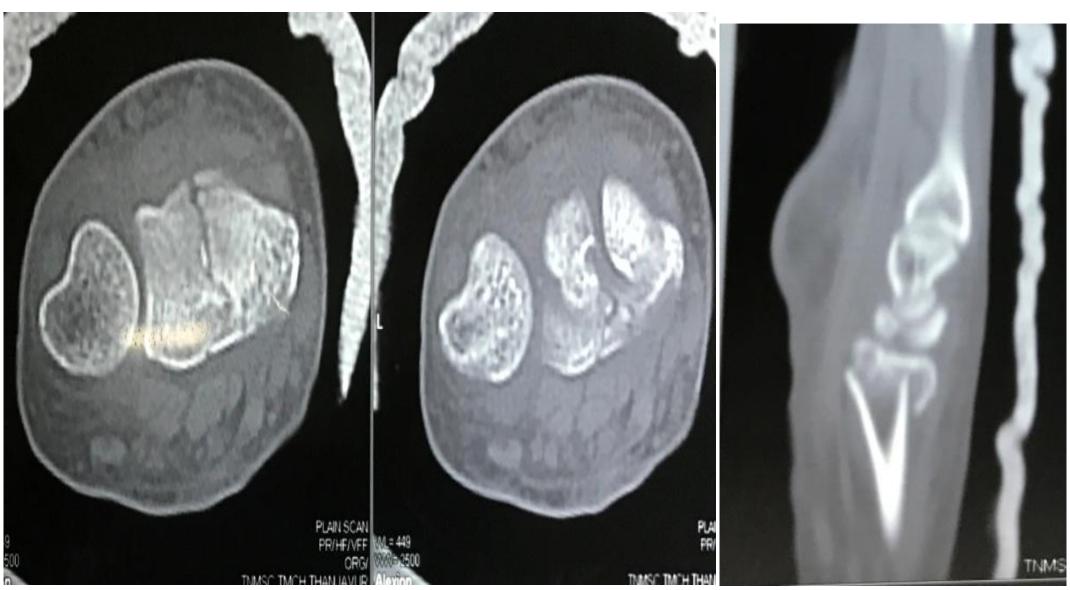
Pre operative CT scan of wrist

Post operative radiograph Anterio posterior and lateral views

Clinical picture showing Volar flexion and Palmar flexion of wrist

Case 2

Pre operative radiograph Anterio posterior and lateral views



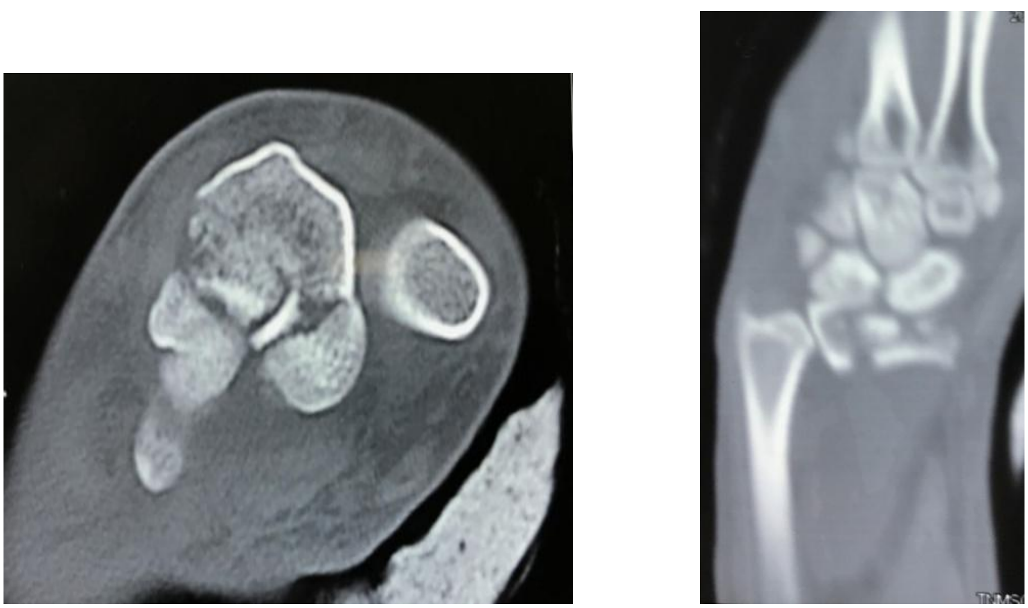
Pre operative CT scan of wrist

Post operative radiograph Anterio posterior and lateral views

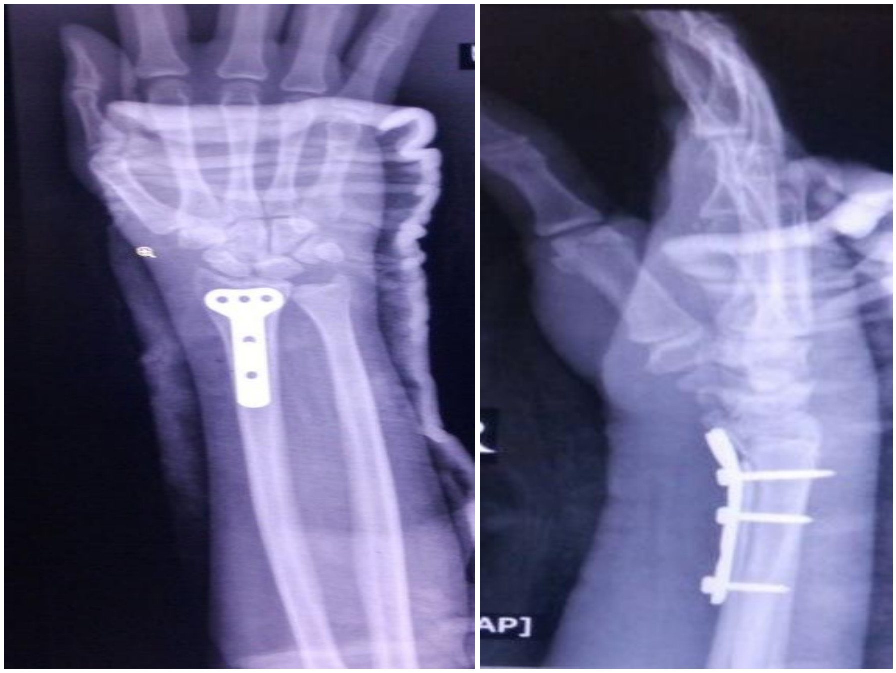
Clinical picture showing Volar flexion and Palmar flexion of wrist

Case3

Pre operative radiograph showing Anterio posterior and lateral views



Pre operative CT scan of wrist

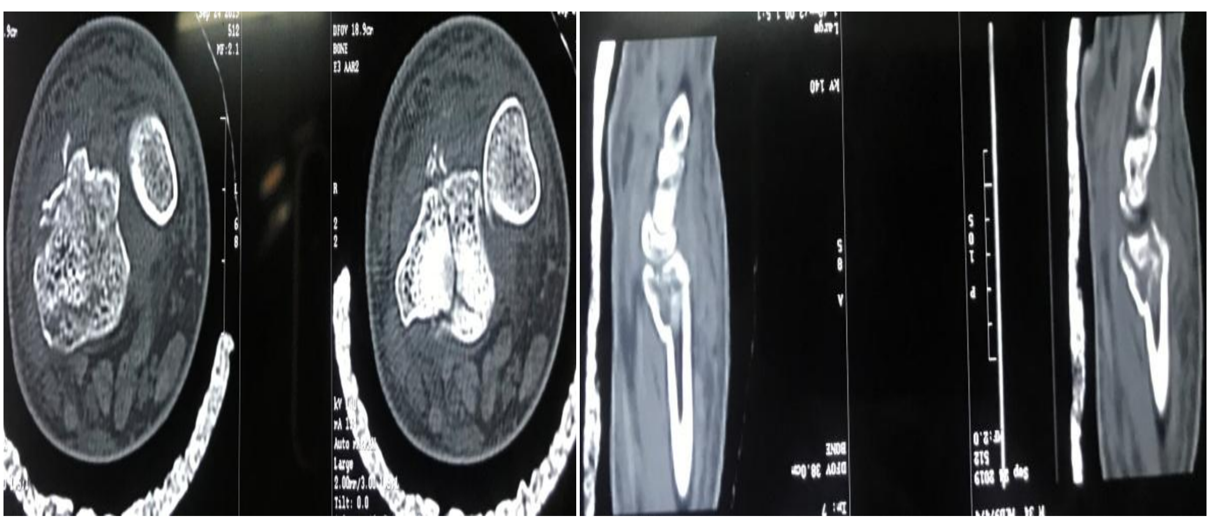


Post operative radiograph Anterio posterior and lateral views

Clinical picture showing Volar flexion and Palmar flexion of wrist

Case4

Pre operative radiograph Anterio posterior and lateral views

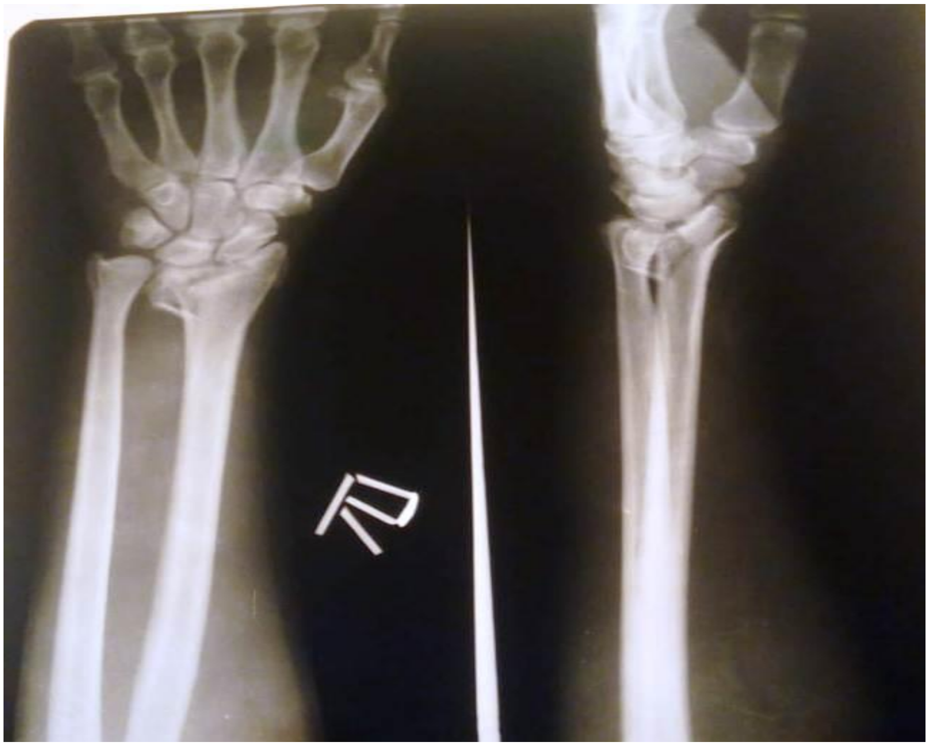


Pre operative CT scan of wrist

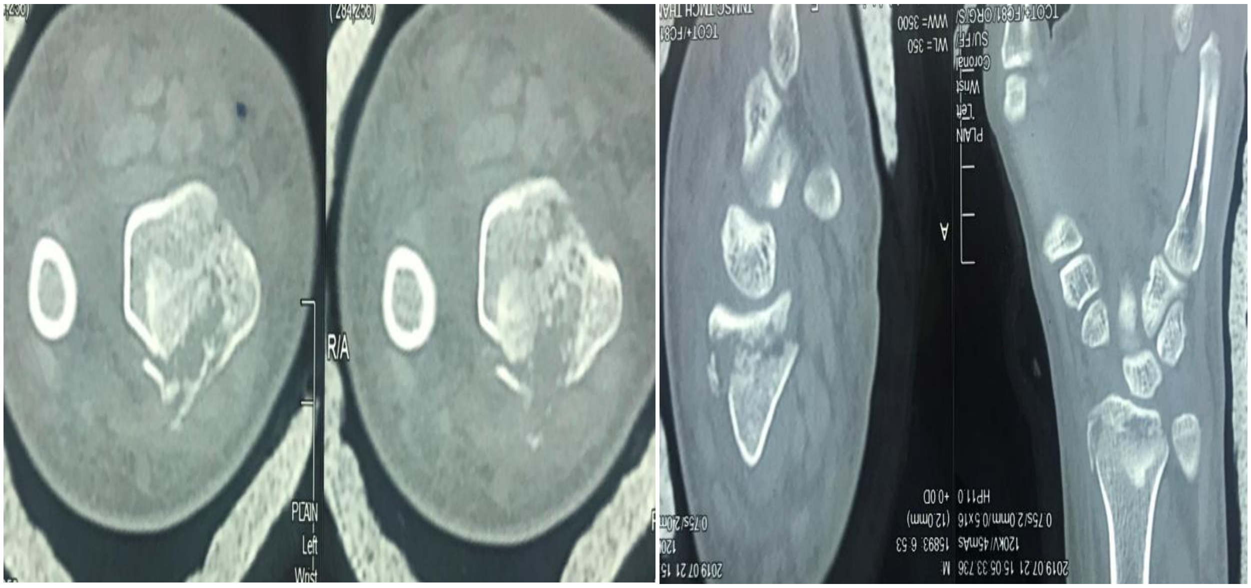
Post operative radiograph Anterio posterior and lateral views

Clinical picture showing Volar flexion and Palmar flexion of wrist

Case 5



Pre operative radiograph showing Anterio posterior and lateral views

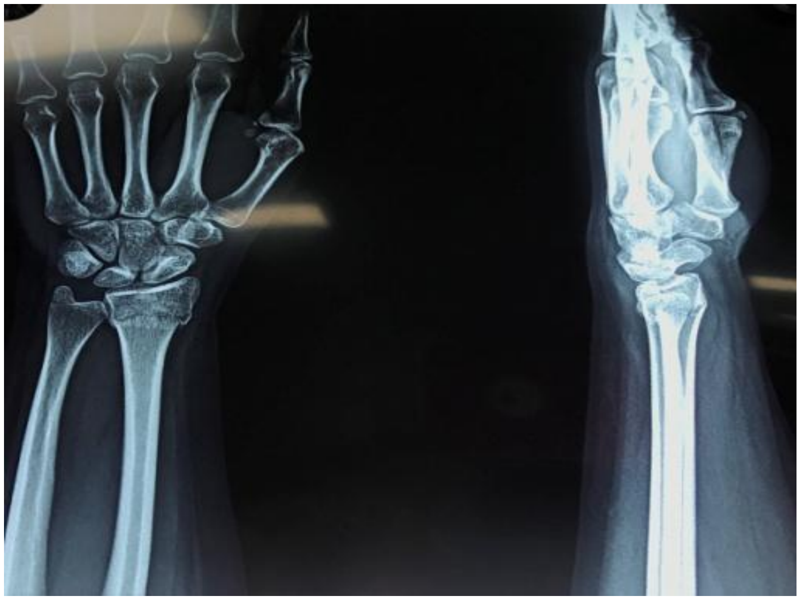


Pre operative CT scan of wrist

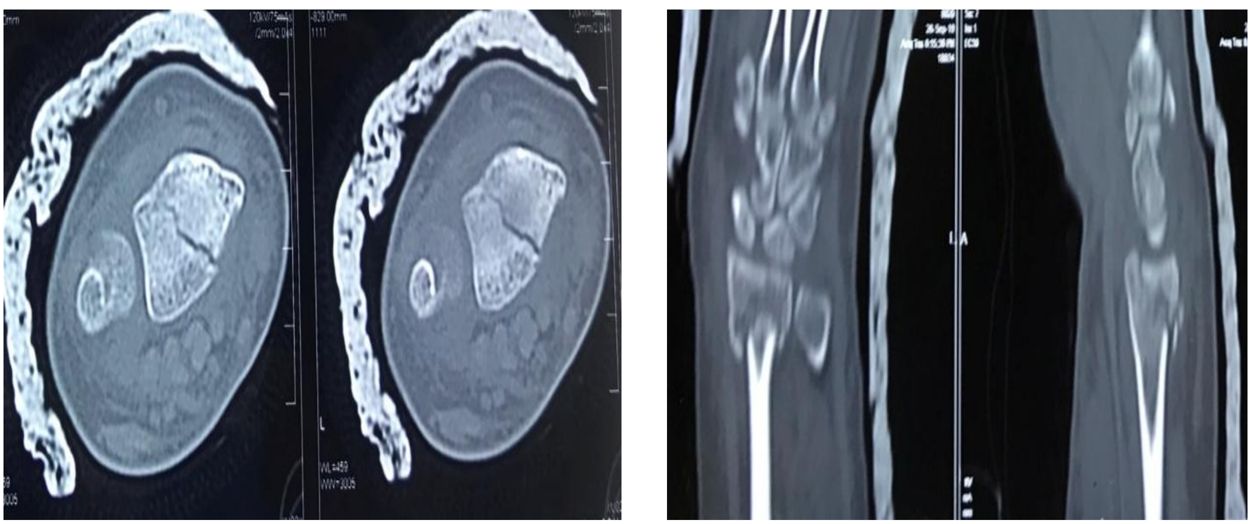
Post operative radiograph Anterio posterior and lateral views

Clinical picture showing Volar flexion and Palmar flexion of wrist

Case 6



Pre operative radiograph showing Anterio posterior and lateral views



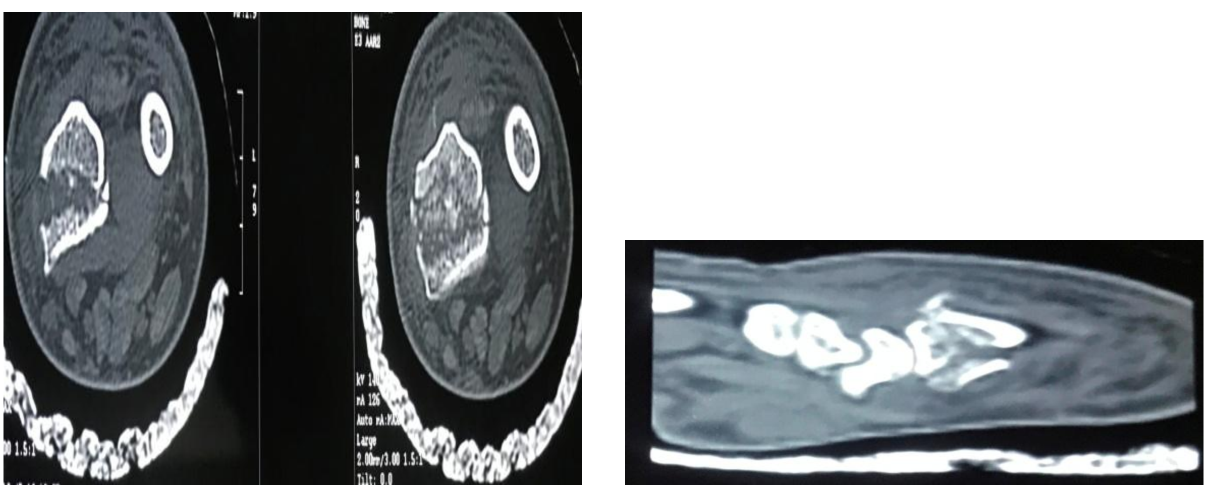
Pre operative CT scan of wrist

Intra -operative C – arm images showing K-wire fixation

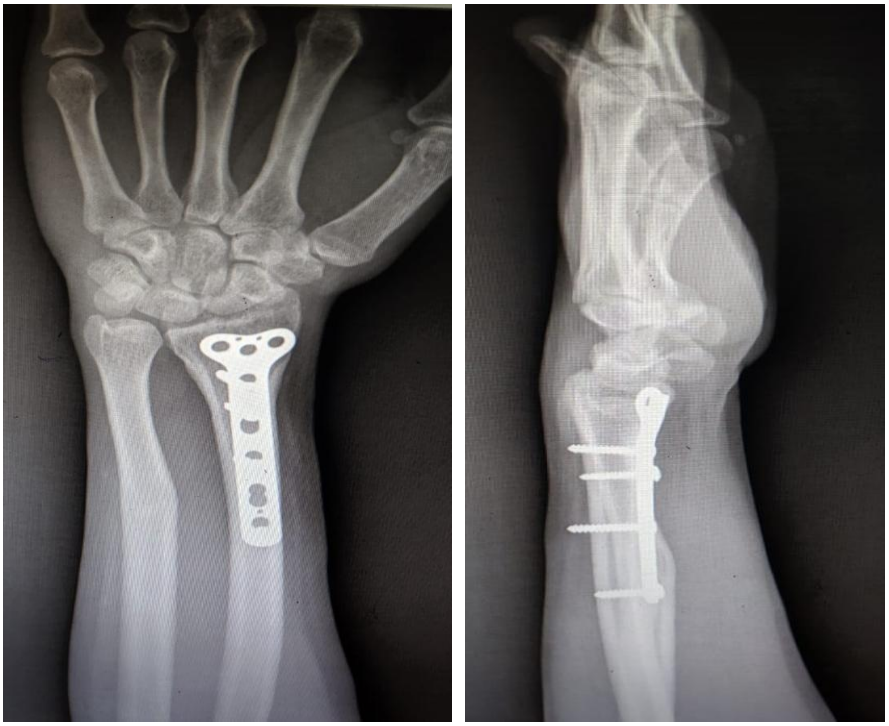
Immediate post operative period patient on slab immobilisation

Case 7

Pre operative radiograph showing Anterio posterior and lateral views



Pre operative CT scan of wrist

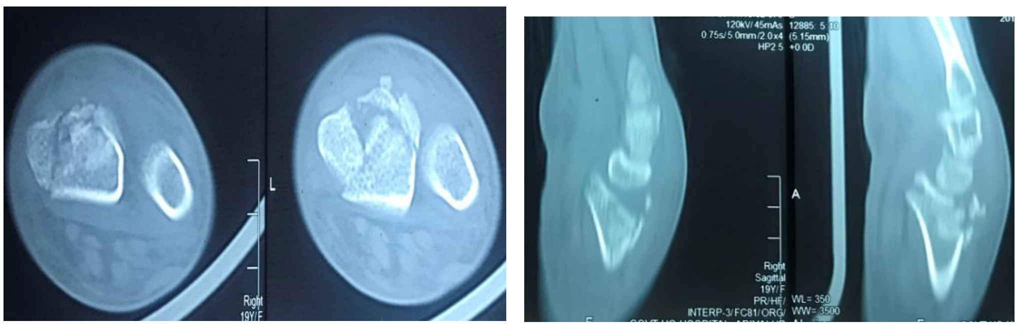


Post operative radiograph Anterio posterior and lateral views

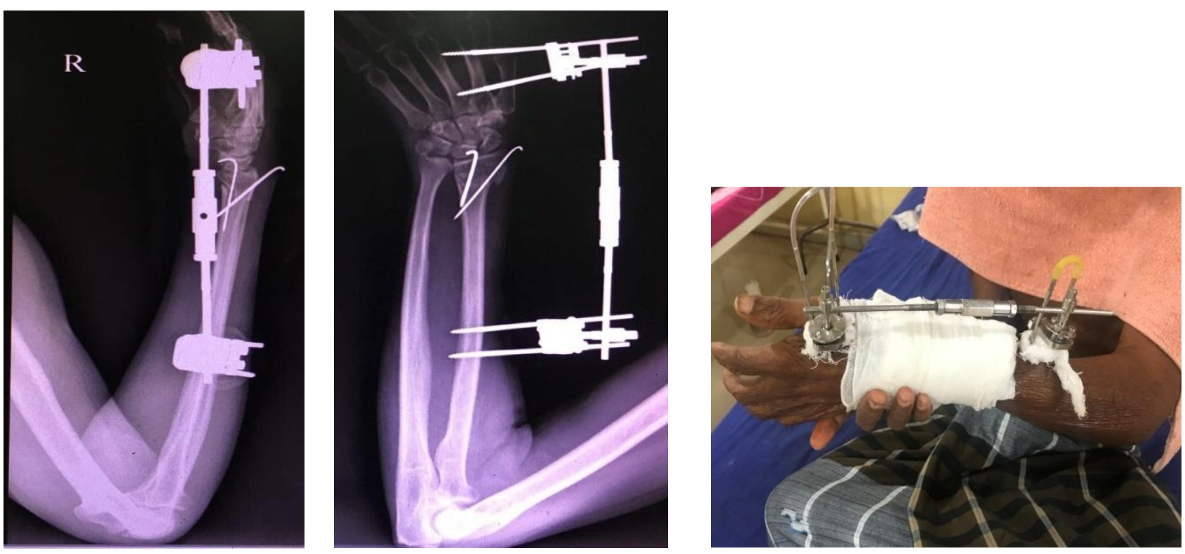
Clinical picture showing Volar flexion and Palmar flexion of wrist

Case 8

Pre operative radiograph showing Anterio posterior and Lateral views



Pre operative CT scan of wrist



Post operative radiograph Anterio posterior and Lateral views

Complications

Screw migration into wrist joint **Keloid formation**

DISCUSSION

Comminuted intra articular fractures of the distal radius are one of the most common fractures in day to day orthopaedic practice and facing much difficulty in producing a satisfactory outcome.

The goals of treatment in unstable distal radius fractures should be

1. Restoration of the normal anatomy and congruency of the articular surface of the distal radius.
2. Stable fixation of the fracture fragments.
3. Early rehabilitation of the wrist and hand and early return to work.
4. To prevent fracture disease.

Table showing details of cases studied

Number of cases	48
Males	26
Females	22
Side of injury	Right-21, Left -27
Mode of injury	Vehicular –19 Accidental fall-29
Implant	Volar plate-19 Ball and socket external fixator-14 K –wire-15
Anaesthesia	Regional Anaesthesia Supraclavicular block
Mean lag time to sugery	4.8 days
Mean follow up	1.2 years
Lost of follow up	2 cases
Mean pre and post reduction radial length	4.33° and 10.29°
Mean pre and post reduction volar tilt	-14.10 °and 6.58°
Mean pre and post reduction radial angulation	10.58° and 18.96°
Mean pre and post reduction ulnar variance	3.13° and 0.71°
Complications	Volar plating-1 External fixation-4 K- wire fixation-2
Gartland and Werley score results (Excellent +Good)	Volar plating -15 External fixation-12 K-wire fixation-14

In our study, functional and anatomical results of 48 patients with intra articular fractures of distal radius treated with

1. Open reduction Volar plating,
2. Closed reduction External fixation and
3. Closed reduction K wire fixation and plaster applied

were analyzed.Our functional analysis is based on Gartland and Werley demerit system, 55.6% of patients in volar plating had excellent results followed by 33.3% in external fixation patients and 11.1% in K- wire fixation patients and 38.2 % of patient had good results in K- wire fixation followed by 35.3% patients volar plating and 26.5%in external fixation patients. There was no poor result in any of our patient .

In our study, anatomical grading is based on Lindstrom and Frykman system, 42.9% patients in volar plating had grade I result i.e. no significant deformity followed by 34.3% in external fixation and 22.9% in K- wire fixation.In volar plating 30% shows grade 2 result i.e slight deformity followed by K- wire method 60% and External fixation 10%.None of our patients in our study had severe deformity(Grade 4).The duration to surgery shows significant p value(0.02) as most of the patients are operated within five days.Mode of injury by accidental fall (60.41%)were more common than vehicular accidents(39.58%). As vehicular accidents victims mostly undervent volar plating(47.4%) due high velocity and metaphyseal communition, followed by External fixation method.In our study, fracture with AO Type B1andB3(partially articular) were mostly operated with K- wire fixation method and fracture with AO Type C2 and C3 (complete articular metaphyseal communition) were mostly operated with Volar plating method.Patients with skin condition not favourable for internal fixation , irrespective of fracture type fixed either with K- wire or external fixation.

In volar plating one patient has intra articular screw migration with secondary collapse and skin complication like keloid formation.In external fixation , one patient developed pin site infection and another developed radial sensory nerve deficit and each patient developed finger stiffness and pin bending complications.In K- wire fixation two patients developed pin site infections.At one year follow up ,80 % of K wire fixation has no pain followed by 63.15% in volar plating and 50% in external fixation. Functional assessment with statistical interference shows about 85.7%(External fixator and K wire) followed by 84.2% were working without any functional disability. There were no patients in volar plating with functional status unable to work.Regarding finger grip strength when compared with patients normal hand about 78.9% has good to excellent results in volar plating patients followed by 78% of excellent results in external fixation patients.

Restoration of normal anatomy is important for restoration of function. Normally 82% of the compressive load across the wrist is borne by distal radius and remaining by distal ulna. With 2.5mm loss of radial length, ulna bears 42% load and at 20 degree dorsal angulation, ulna bears 50% load.(42)

Preservation of radial length is the most important factor for preservation of function. Loss of radial length can lead to ulnar impaction or dysfunction of Distal Radio Ulnar Joint, with limited range of motion in pronation and supination, depending on the volar or dorsal subluxation of the ulnar head within the sigmoid notch.Residual dorsal angulation can precipitate ulnar impaction,midcarpal instability and altered stress concentration which may

lead to early arthritis. Porter, in his study, felt that loss of function did not occur until at least 20 degrees of palmar tilt was lost.[(43)]In ligamentotaxis with external fixation, radial length,ulnar variance and radial angulation are restored to normal but correction of volar tilt though adequate, is not complete. This is attributed to the fact that volar ligaments are stronger and become taut on distraction before the dorsal ligaments which are in a relative ‘Z’ orientation. So, on distraction, palmar cortex is brought out to length before dorsal cortex preventing full correction of dorsal tilt.[(43)]

LIMITATIONS

Our study has some of the limitations because it is a comparative study of prospective design, we have only limited number of cases in the stipulated period and also there is only short term follow up of most cases. Another limitation is different subtypes of fracture pattern are not fixed with same method of fixation.

CONCLUSION:

When the outcome of different fixation methods were assessed, in 48 cases of closed comminuted distal radius fracture at one year follow up, there were no major differences in the functional outcome in terms of pain, range of movements, grip strength and return to work.Among the treatment by all the three methods (Volar plate,External fixation and K-wire with plaster immobilization),eventhough there is no statistical difference in the functional outcome, volar locking plate is far better than external fixator and K- wire fixation, in specific radiological parameters like volar tilt, radial inclination and intraarticular step off.It is also successful in achieving patient‘s satisfaction with limited number of minor complications and early return to work.

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GARTLAND & WERLEY SYSTEM TO EVALUATE RESULTS OF HEALED # DISTAL RADIUS (DEMERIT POINT RATING SYSTEM)

RESIDUAL DEFORMITY	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	3
SUBJECTIVE EVALUATION	
EXCELLENT: no pain, disability or limitation of movement	0
GOOD: occasional pain, slight ↓ of motion, no disability	2
FAIR: occasional pain, limitation of movement, feeling of weakness, activities slightly restricted	4
POOR: pain, loss of motion, disability, activities more or less restricted	6
OBJECTIVE EVALUATION	
Dorsiflexion < 45°	5
Loss of ulnar deviation < 15 °	3
Supination < 50 °	2
Pronation < 50 °	2
Palmar flexion < 30 °	1
Radial deviation < 15 °	1
Loss of Circumduction	1
Pain in DRUJ	1
Grip strength 60 % or less to opposite side.	1
COMPLICATION	
Arthritic change – minimum	1
Arthritic change – minimum with pain	2
Arthritic change – moderate	3
Arthritic change – moderate with pain	4
Arthritic change – severe	4
Arthritic change – severe with pain	5
Nerve complication	1-3
Loss of finger motion	1-3

POINTS	RESULTS
0 – 2	Excellent
3 – 8	Good
9 – 20	Fair
21 & above	Poor

LINDSTROM AND FRYKMAN CRITERIA FOR ANATOMICAL RESULT

	DEFORMITY	DORSAL ANGULATION	RADIAL SHORTENING
GRADE I	No significant deformity	Not exceeding neutral	< 3mm
GRADE II	Slight deformity	1 – 10 °	3 – 6 mm
GRADE III	Moderate deformity	11 – 14 °	7 – 11 mm
GRADE IV	Severe deformity	> 14 °	> 11 mm

CLINICAL PROFORMA

1. Name

2. Age

3. Sex

4. In-Patient no.

5. Mode of injury

6. Side of injury

7. Dominant side

8. AO type

9. Associated injury

10. Associated compliations

11. Date of injury

12. Date of surgery / plaster immobilization

13. Date of fixator / plaster removal

14. Preoperative radiology

Radial length –

Volar tilt –

Radial angulation -

Ulnar variance –

Dorsal comminution –

15. Post operative radiology

Radial length –

Volar tilt –

Radial angulation -

Ulnar variance –

16. Pin site infection

17. Pin site loosening

THREE MONTHS:

18. Stiffness

19. Pain

20. Functional status

21. Median nerve deficit

22. Radial sensory nerve deficit

23. Tendon rupture

24.

MOVEMENT	ROM	% OF NORMAL
Palmar flexion		
Dorsi flexion		
Radial deviation		
Ulnar deviation		
Supination		
Pronation		

25.

	FINDINGS	DIFFERENCE FROM NORMAL
Radial length		
Volar tilt		
Radial angulation		
Ulnar variance		

26. Grip strength - (% 0f opposite side)

MOVEMENT ROM % OF NORMAL

Palmar flexion

Dorsi flexion

Radial deviation

Ulnar deviation

Supination

Pronation

SIX MONTHS

27. Stiffness

28. Pain

29. Functional status

30. Median nerve deficit

31. Radial sensory nerve deficit

32. Tendon rupture

33.

MOVEMENT	ROM	% OF NORMAL
Palmar flexion		
Dorsi flexion		
Radial deviation		
Ulnar deviation		
Supination		
Pronation		

34

	FINDINGS	DIFFERENCE FROM NORMAL
Radial length		
Volar tilt		
Radial angulation		
Ulnar variance		

35. Grip strength - (% 0f opposite side)

MOVEMENT ROM % OF NORMAL

Palmar flexion

Dorsi flexion

Radial deviation

Ulnar deviation

Supination

Pronation

ONE YEAR:

36. Stiffness

37. Pain

38. Functional status

39

MOVEMENT	ROM	% OF NORMAL
Palmar flexion		
Dorsi flexion		
Radial deviation		
Ulnar deviation		
Supination		
Pronation		

40

	FINDINGS	DIFFERENCE FROM NORMAL
Radial length		
Volar tilt		
Radial angulation		
Ulnar variance		

41. Grip strength - (% 0f opposite side)

42. Lindstrom and Frykman anatomical grade: I / II / III / IV

43. Gartland and Werley demerit score:

44. RESULT: Excellent / Good / Fair / Poor.+

Key to Master Chart

Sex : M - Male

F - Female

Side of injury: R - Right

L – Left

Mode of injury:Vehicular accident-1

Accidental fall – 2

Time duration to surgery

RL - Radial length

VT - Volar tilt

RA - Radial angulation

UV - Ulnar variance

DC - Dorsal comminution

complicn - Complication

Pi - Pin site infection

Pain N - Nil

M - Mild

Mo - Moderate

Fn status - Functional status

W - Working

R - Restricted work

U - Unable to work

PF - Palmar flexion

DF - Dorsi flexion

RD - Radial deviation

UD - Ulnar deviation

SP - Supination

PR - Pronation

GS - Grip strength

Df fr N - Difference from Normal

G and W score - Gartland and Werley score

L and F grade - Lindstrom and Frykman grade

MASTER CHART - EXTERNAL FIXATION

S.NO	Age	SEX	Side of Injury	Mode of Injury	Ao type	Dur. to Surg.	PRE REDUCTION				DC	POST REDUCTION				COMPLICATION	PAIN	FUNCTIONAL STATUS	STIFFNESS	OUTCOME IN %					DIFF. FROM NORMAL						GWSCORE	LF SCORE	RESULTS
							RL	VT	RA	UV		RL	VT	RA	UV					PF	DF	RD	UD	SP	PR	GS	RL	RA	VT	UV			
1	37	F	L	ACC. F	B2	1	5	-22	12	3	-	10	10	20	1	N	N	W	-	95	92	96	97	100	100	90	0	0	3	0	2	I	E
2	48	F	L	ACC. F	B3	2	4	-30	10	4	-	11	5	15	0	Y	MI	W	-	90	94	97	95	98	98	92	0	5	6	0	5	I	E
3	44	M	R	ACC. F	C1	1	3	-22	8	5	+	10	8	18	2	Y	N	W	-	92	94	95	95	95	95	95	2	3	4	1	4	I	E
4	35	M	L	RTA	C2	1	3	-20	5	2	+	12	12	22	0	N	MI	W	-	88	100	100	100	88	100	90	0	0	0	0	2	I	E
5	50	F	L	ACC. F	C3	1	-2	-24	10	8	+	10	4	18	2	N	MI	W	+	78	88	95	95	88	88	75	2	6	4	1	6	I	G
6	40	F	R	RTA	B2	1	-4	-30	0	6	-	10	8	20	0	N	N	W	-	100	100	100	100	88	100	96	2	2	0	0	5	I	E
7	32	M	R	ACC. F	B1	1	8	0	15	3	-	11	10	22	1	N	N	W	-	100	100	100	100	100	100	95	0	2	0	0	3	I	E
8	50	M	L	ACC. F	B2	1	4	-20	10	2	-	11	8	20	1	N	N	W	-	88	100	100	100	88	88	90	0	3	0	0	4	I	E
9	35	F	R	RTA	B3	1	5	-22	16	2	+	12	5	22	0	N	N	W	-	88	100	100	100	88	88	85	0	5	0	0	2	I	G
10	47	M	R	ACC. F	B3	1	2	-26	12	4	+	9	-4	18	0	Y	3	U	+	88	95	95	100	95	95	95	2	13	2	0	12	III	P
11	37	M	R	RTA	C2	1	5	16	14	6	+	12	11	20	-1	N	N	W	-	96	100	100	100	100	100	98	0	0	2	0	4	I	E
12	50	F	R	ACC. F	B3	2	4	-36	15	3	-	10	-2	20	0	Y	MI	R	-	85	88	100	80	84	84	75	2	12	2	0	10	II	G
13	48	F	L	ACC. F	B2	1	3	-20	5	2	-	12	12	22	0	N	MI	W	-	88	100	100	100	88	100	90	0	0	0	0	1	I	E
14	28	M	R	RTA	C3	1	2	20	8	6	+	10	10	16	1	N	MI	W	+	98	98	95	95	100	100	90	2	3	6	2	6	I	E

MASTER CHART - K WIRE FIXATION

S.NO	Age	SEX	Side of Injury	Mode of Injury	Ao type	Dur. To Surg.	PRE REDUCTION				DC	POST REDUCTION				COMPLICATION	PAIN	FUNCTIONAL STATUS	STIFFNESS	OUTCOME IN %						DIFF. FROM NORMAL					GWSCORE	LF SCORE	RESULTS
							RL	VT	RA	UV		RL	VT	RA	UV					PF	DF	RD	UD	SP	PR	GS	RL	RA	VT	UV			
1	50	F	L	ACC.F	B1	2	5	-20	10	2	-	8	8	22	1	N	N	W	+	90	90	95	95	100	100	95	2	2	0	1	1	I	E
2	38	M	L	RTA	B3	1	3	-22	15	2	+	10	8	21	1	N	N	W	-	80	80	75	70	95	95	80	4	12	4	1	6	II	G
3	40	F	R	ACC.F	B3	1	4	-25	12	3	+	9	10	12	0	N	N	W	-	90	90	95	95	100	100	90	2	7	2	0	3	I	G
4	45	F	R	ACC.F	B3	1	6	-22	15	1	+	10	5	18	1	N	N	W	-	90	85	80	80	95	95	82	0	8	6	1	6	I	G
5	39	F	L	ACC.F	C1	1	4	-20	12	3	-	9	5	15	1	N	N	W	+	80	70	90	90	90	90	75	3	13	5	2	8	II	G
6	25	M	R	RTA	B1	1	4	-22	14	1	-	9	10	18	1	N	N	W	-	100	100	98	98	100	100	90	1	8	4	0	5	I	G
7	48	M	L	ACC.F	C1	1	5	-20	12	4	+	10	5	17	2	N	N	W	-	70	75	85	85	90	90	78	3	12	5	0	7	II	G
8	30	F	L	ACC.F	B2	1	-3	-20	11	2	+	12	12	20	0	N	N	W	-	90	90	95	95	100	100	85	5	8	4	1	4	I	G
9	47	M	L	ACC.F	C2	1	5	-26	10	3	-	12	14	23	1	N	N	W	-	85	75	80	80	90	90	70	4	12	4	1	7	II	G
10	42	M	R	ACC.F	C3	1	5	-30	8	4	+	8	-10	18	2	Y	MI	U	-	65	70	72	72	80	80	60	8	15	7	1	11	III	F
11	35	F	L	RTA	B3	1	7	-25	8	2	+	9	8	12	2	Y	MI	R	+	70	70	75	75	85	85	65	3	12	4	2	5	II	G
12	28	M	L	RTA	B2	1	5	-25	15	1	+	10	10	15	1	N	N	W	-	98	98	98	98	100	100	85	1	2	5	0	4	I	G
13	25	F	R	RTA	B1	1	8	-20	8	2	-	8	10	15	1	N	N	W	-	95	95	100	100	95	95	90	2	5	4	0	5	I	G
14	43	F	L	ACC.F	B3	1	6	-30	10	3	-	12	-5	20	2	N	MI	R	-	75	75	85	85	90	90	82	5	14	3	1	4	II	G
15	40	M	L	ACC.F	C1	1	5	-15	12	1	+	10	12	20	1	N	N	W	-	95	95	95	95	100	100	90	2	4	2	0	4	I	G

MASTER CHART - VOLAR PLATING

S.NO	Age	SEX	Side of Injury	Mode of Injury	Ao type	Dur. To Surg.	PRE REDUCTION				DC	POST REDUCTION				COMPLICATION	PAIN	FUNCTIONAL STATUS	STIFFNESS	OUTCOME IN %							DIFF. FROM NORMAL				GWSCORE	LF SCORE	RESULTS
							RL	VT	RA	UV		RL	VT	RA	UV					PF	DF	RD	UD	SP	PR	GS	RL	RA	VT	UV			
1	27	M	R	RTA	C3	1	4	-10	10	5	+	10	5	20	1	N	MI	W	-	95	95	90	90	100	100	90	2	7	5	1	5	I	G
2	41	M	R	ACC.F	B3	1	8	20	10	2	-	10	10	20	1	N	N	W	-	90	90	90	90	95	95	92	3	4	5	0	4	I	G
3	50	F	R	ACC.F	B3	2	6	16	12	3	-	11	12	22	0	N	N	W	-	98	98	95	95	100	100	92	0	1	1	0	2	I	E
4	30	M	L	RTA	C2	1	4	-25	12	1	+	9	10	12	0	N	N	W	-	100	100	95	95	95	95	85	1	2	7	0	3	I	G
5	47	M	L	ACC.F	C3	1	5	-20	5	4	+	8	5	15	2	N	MO	W	+	80	80	70	80	80	80	75	4	10	7	2	9	II	F
6	45	F	L	ACC.F	C2	2	3	-16	14	4	+	10	5	18	0	N	MI	W	-	95	90	90	90	100	100	92	0	7	2	0	4	I	G
7	29	M	L	RTA	C3	1	2	18	10	3	+	12	8	20	-1	N	N	W	-	100	100	98	98	98	98	95	0	2	0	0	2	I	E
8	40	M	R	RTA	C2	2	4	-14	5	5	+	11	4	20	2	N	MO	R	+	70	75	65	65	80	80	60	7	-10	12	4	12	III	F
9	38	F	L	RTA	B3	1	4	22	15	2	+	11	8	20	1	N	N	W	-	98	98	98	95	100	100	93	0	2	2	0	1	I	E
10	25	M	L	RTA	B2	1	5	26	8	3	-	9	9	22	1	N	N	W	-	98	98	98	98	100	100	95	4	4	0	1	4	I	G
11	49	F	R	ACC.F	C1	2	9	-5	15	1	+	11	12	20	-1	N	N	W	-	100	100	100	100	100	100	95	0	0	0	0	1	I	E
12	42	F	R	ACC.F	C2	2	3	-10	8	7	+	10	10	18	2	N	N	W	-	95	95	92	92	90	90	85	3	0	5	3	4	I	G
13	22	M	R	RTA	C2	1	6	-4	10	6	-	12	10	22	1	N	N	W	-	92	92	95	95	100	100	90	0	3	1	1	3	I	G
14	30	F	R	ACC.F	B1	1	9	-12	16	2	-	11	12	20	-1	N	N	W	-	100	100	98	98	100	100	88	1	2	4	0	4	I	G
15	45	M	L	ACC.F	B2	2	4	-20	10	2	-	12	8	22	1	N	N	W	-	88	100	100	100	88	90	80	0	6	0	0	5	I	G
16	32	M	L	RTA	B3	1	5	-22	16	2	-	11	5	22	0	N	MO	W	+	90	95	80	88	88	90	70	1	6	0	0	5	I	G
17	50	M	L	ACC.F	C3	2	4	-35	10	4	+	12	-35	20	1	Y	MO	R	-	89	90	65	100	100	100	65	0	13	4	1	5	II	G
18	43	M	L	RTA	B1	2	7	2	4	2	-	10	10	20	-1	N	N	W	-	95	90	90	95	100	100	85	2	0	4	0	1	I	E
19	37	F	L	ACC.F	C1	2	5	-10	6	2	-	8	9	18	1	N	MO	R	+	75	70	75	82	72	70	60	6	12	8	2	8	II	G