Evaluation of functional and radiological outcomes following management of Volar Barton fracture fixed with Variable Locking Plate

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

In partial fulfilment of the requirements for the degree of

MASTER OF SURGERY

IN

ORTHOPAEDICS

Under the Guidance of

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ABSTRACT:

Background: A Volar or reverse Barton fracture refers to an intra-articular distal radius fracture that extends out to the volar aspect of the distal radius and there may be subluxation or dislocation in that direction. The overall goal of managing Volar Barton fractures is to obtain motion which is pain free and allowing the patient to return to their usual activities and to minimise the risk of development of early onset arthritis which may cause disability. Though various management options are available, this study deals with the assessment of functional and radiological outcomes of Volar Barton fracture fixed with Variable locking plate.

Material and Methods: A prospective, observational and hospital-based study conducted at R. L. Jalappa Hospital and Research Centre, SDUMC, Tamaka on patients with Volar Barton fracture managed with Variable locking plate during the period of December 2019 to June 2021. Clinical data is collected with DASH score, Gartland and Werley demerit criteria and Sarmiento modification of Lindstrom criteria.

Results: 40 subjects with mean age of 36.43 ± 10.59 years were included for the study. The mean flexion, extension, supination and pronation was 70.63° ± 3.6°, 74.3° ± 3.64°, 79.83° ± 2.67° and 76.28° ± 1.99° degrees respectively at the end of 6 months. Based on Gartland and Werley outcome, majority (65%) of the study population to have excellent outcome, 30% had good outcome and only 5% had fair outcome. The mean DASH score was 13.98 ± 5.76. Among the study population, 22 had good radiological outcome, 11 had excellent outcome and 7 had fair outcome.

Conclusion: The study concludes that fixation of Volar Barton fractures with Variable Locking plates have a betterment role in terms of immediate stability, maintaining anatomic reduction and early mobilisation. It also provides better functional outcome and a good anatomical reduction.

Keywords: Volar Barton fracture, VA-LCP, Range of motion, DASH, Gartland and Werley demerit criteria, Sarmiento modification of Lindstrom criteria.

LIST OF ABBREVIATIONS

GLOSSARY	ABBREVIATIONS
AO	Arbeitsgemeinschaft für Osteosynthesefragen
DASH score	Disability of Arm, Shoulder and Hand score
TFCC	Triangular Fibro Cartilage Complex
DRUJ	Distal Radio Ulnar Joint
APL	Abductor Pollicis Longus
EPB	Extensor Pollicis Brevis
FDP	Flexor Digitorum Profundus
AP	Antero Posterior
PA	Postero Anterior
OTA	Orthopaedic Trauma Association
CT	Computerized Tomography
MRI	Magnetic Resonance Imaging
ORIF	Open Reduction Internal Fixation
CRPS	Complex Regional Pain Syndrome
VA LCP	Variable Angle Locking Compression Plate
LCP	Locking Compression Plate
FOOH	Fall On Outstretched Hand
GW	Gartland and Werley

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INTRODUCTION

Fractures of distal radius are one among the most common fractures of upper extremity seen in the emergency room. This type of injuries has likely been common since the human existed but Petit, Pouteu and Colles described it first as the injury might be due to fracture but not due to dislocation.[1,2]

Based on the variables, the distal radius is vulnerable to various forms of fractures such as age, sex, mechanism of injury, bone quality and transfer of energy. Many eponyms are used on a regular basis to describe the distal radius fractures. They are useful in giving idea about the pattern of fracture and also used for treatment determination and prognosis such as Colle’s fracture, Smith fracture, Barton fracture, Chauffer’s fracture.[3]

The distribution of these fractures is bimodal with high energy fractures mostly seen in young men and low energy fractures seen in old women. The second most common fracture in the elderly are the fractures of distal radius and the incidence is higher in females when compared to males in the ratio by the factor of two to three.[4]

Barton’s fracture is titled after the American Surgeon John Rhea Barton. The Barton fracture refers to an intra-articular distal radius fracture extending through the dorsal cortex of the radius, often with dislocation or dorsal subluxation of the radiocarpal joint.[5] A volar or reverse Barton describes a fracture that extends out the volar aspect of the distal radius and there may be subluxation or dislocation in that direction.[2]

Barton’s fracture account for 1.2% to 4.2% of all distal radius fractures. Based on the site and shifting direction of fragments they are classified as dorsal or Volar Barton fractute.[6]

According to AO classification, Volar Barton fractures are classified under type B3 fractures of the distal radius. Conservative management options are frequently not effective and can result in complications such as osteoarthrosis, subluxation, deformity and instability.[6]

The treatment goal of Volar Barton fracture is to achieve good reduction and stability to achieve the fracture which will help in early wrist mobilization and to avoid the complications.[7] Fracture healing depends on the following factors: Blood supply, gap and stability.[8]

Various management options are documented in the literature, but internal fixation by open reduction using volar plate system is currently used for fixation of Volar Barton fracture as it helps in good reduction and provides better stability. Moreover, the patient can be mobilized early with less chance of developing joint stiffness.[9]

Variable-angle locked plating has been developed to provide higher flexibility and the advantage of allowing fragment specific capture or avoiding intra-articular placement of screws.[10]

The compressive forces exerted on the bone is reduced by the locking plates usage and it helps in achieving stability and prevent the impairment of blood supply and periosteal compression[11] which is favourable towards the fracture union. The locking screws supports the underlying bone and the axial forces are resisted.[12] The achievement of primary stability with a locking screw prevents the secondary displacement regardless of the bone quality.[13] It also allows the patient for early postop rehabilitation.[14]

AIMS & OBJECTIVES

AIMS AND OBJECTIVES

1. To assess Functional outcomes of Volar Barton fractures treated with Variable locking plates by using Disability of Arm, Shoulder and Hand score (DASH score) and Gartland and Werley demerit criteria

2. To assess Radiological outcomes of Volar Barton fractures treated with Variable locking plates by using Sarmiento modification of Lindstrom criteria

REVIEW OF LITERATURE

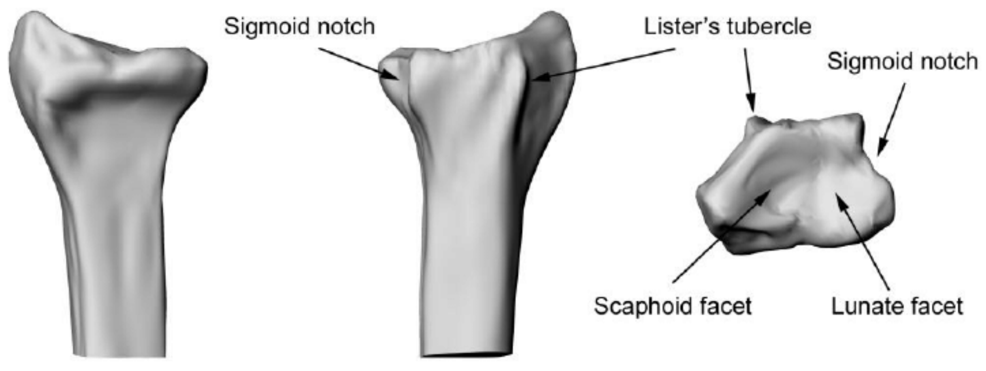
REVIEW OF LITERATURE

ANATOMY:

Distal radius and ulna are integral part in wrist joint and the restoration of their normal anatomy helps to mobilize the wrist and raise the ability to transmit the axial load. The main function of wrist joint is to maintain the position of hand and it allows full hand function. Hand function will have a detrimental effect due to the malunited distal radius fractures.

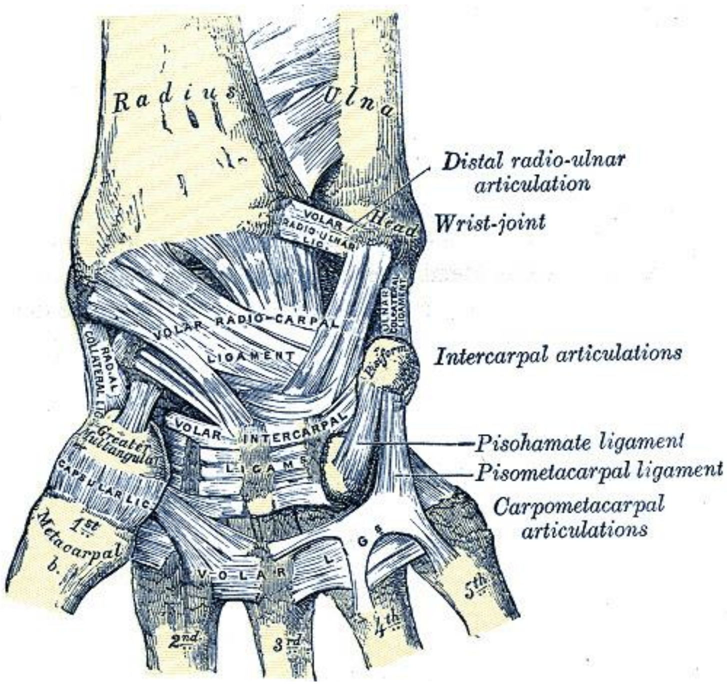
The anatomy of distal radius is unique. Radial articular surface is biconcave, triangular and covered with hyaline cartilage. It has two facets: a triangular lateral facet for scaphoid articulation and a quadrilateral medial facet for articulation of lunate. The medial surface of distal radius has a semicircular notch for ulnar head articulation. This articulation helps the radius to swing around ulna. The lateral surface elongates into a prominent process called radial styloid which gives attachment to the brachioradialis muscle.[15]

Figure 1: Anatomy of distal radius [16]



The palmar surface of the radius forms a curve, concave from proximal to distal. It is relatively smooth, which allows easy contouring of plates in this area. It also allows attachment of radiocarpal ligaments, which act as restraints to the normal tendency of the carpus to slide in an ulnar and palmar direction. The curve is covered by the transverse fibres of pronator quadratus, which has its attachment in the radial side.

Figure 2: Distal Radioulnar anatomy[17]



The distal portion of radius has the cross section, quadrilateral in shape including the epiphyseal and metaphyseal regions. Anatomic portion has four surfaces and dorsal tubercle and styloid process. The four surfaces are medial, lateral, anterior and posterior. The anterior surface is concave shaped extending from radial styloid radially and ulnarly to Triangular Fibro Cartilage Complex (TFCC). It extends distally and towards the ulnar side to lunate, capitate and triquetrum.[18]

Fig. 3 Anterior, Medial, Posterior, Lateral surface [18]

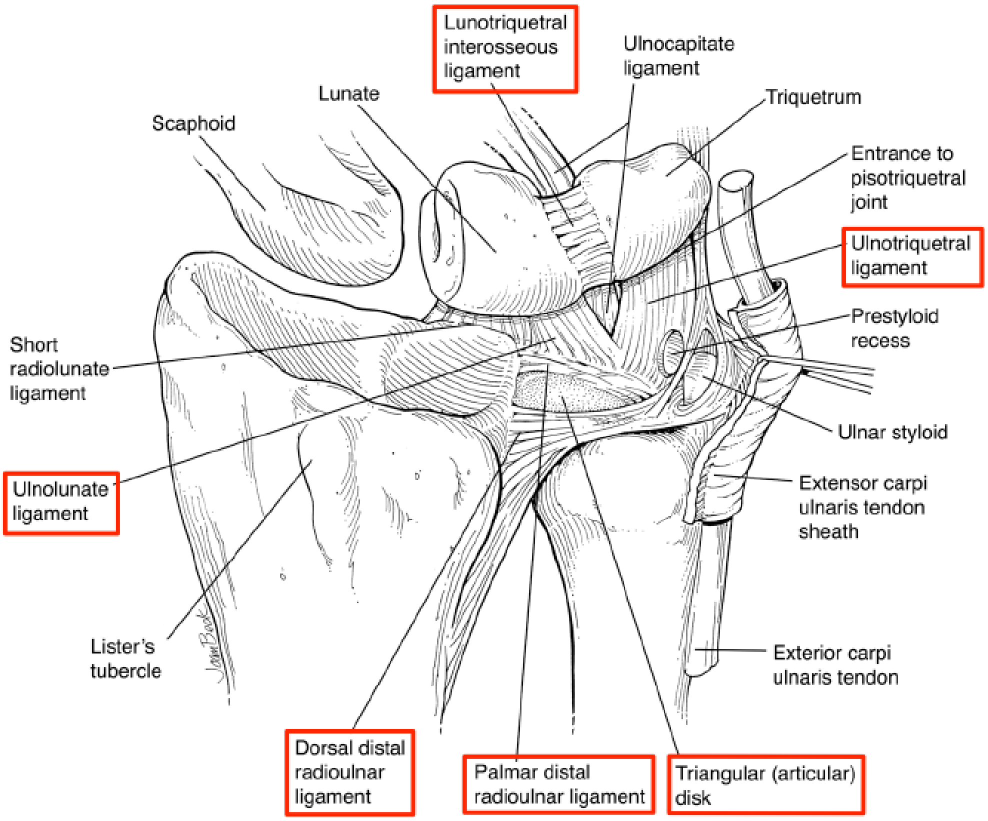
LIGAMENTS OF DISTAL RADIUS:

Triangular Fibro Cartilage Complex:

TFCC is a cartilaginous and ligamentous structure that helps in suspending distal radius and ulnar carpus from the distal ulna. It stabilises the ulnocarpal and radiocarpal joints. It also helps in transmission and distribution of load from carpus to ulna and helps in complex movements occurring at the wrist. It is made of

1. Articular disc
2. Meniscus homologue
3. Ulnar collateral ligament
4. Dorsal and palmar radio-ulnar ligaments
5. Floor of extensor carpi ulnaris subsheath
6. Ulnolunate and Ulnotriquetral ligaments [19]

<u>Figure 4: Anatomy of Triangular Fibro Cartilage Complex[20]</u>



The extrinsic ligaments help in connecting the carpus and the forearm bones. They tend to be stronger than the intrinsic ligaments.

Extrinsic palmar carpal ligaments [21]:

1. **Radio scaphocapitate ligament:** It gets the origin from the styloid process of radius and the palmar lip of radius. It has three parts.

   Radial part: Inserts on the lateral aspect of waist of scaphoid (Radial collateral ligament)

   Middle part: Inserts to the distal pole of scaphoid

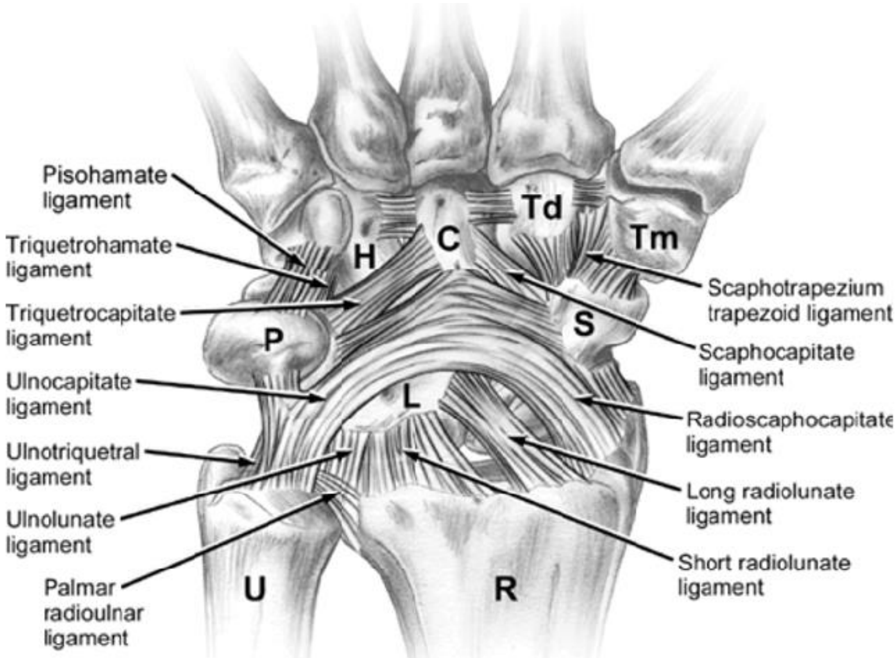
   Ulnar part: Blends with the TFCC to form arcuate ligament over the palmar aspect of capitate

2. **Long radiolunate ligament:** It arises adjacent to the radioscaphocapitate ligament on the palmar lip of radius and gets inserted over the palmar horn of lunate.

3. **Radio scapholunate ligament:** It is covered by thick synovial lining and an important landmark in wrist arthroscopy.

4. **Short radiolunate ligament:** Arises from the palmar lip of the fossa of lunate and passes directly to palmar horn of lunate. On the ulnar aspect its fibers blends with the palmar TFCC complex.

Figure 5: Extrinsic palmar carpal ligaments[22]



Extrinsic dorsal carpal ligaments:

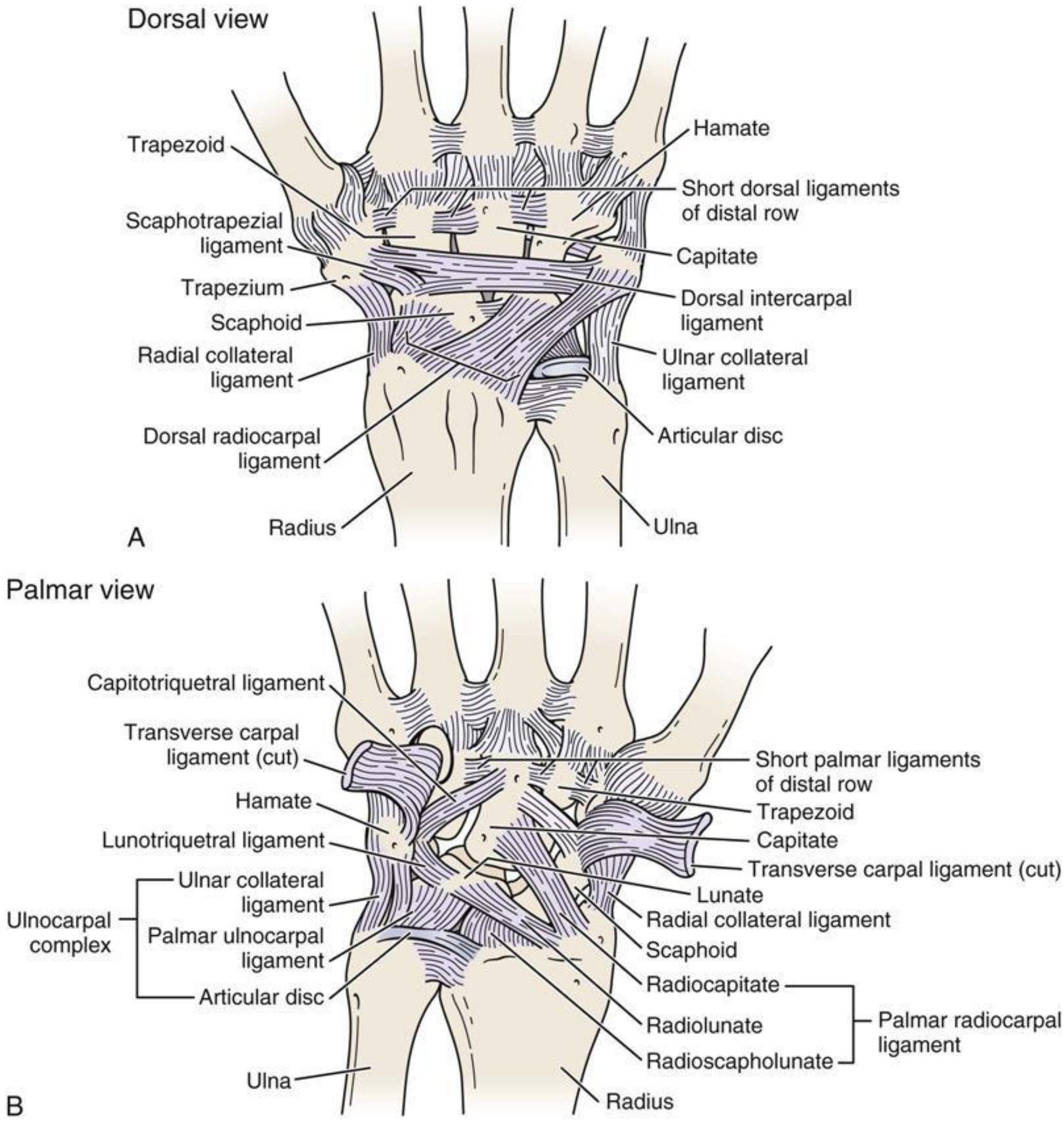
1. **Dorsal radio lunotriquetral ligament:** It has superficial and deep components

   Superficial part: Connects radius with triquetrum

   Deep part: Connects radius, lunate with triquetrum

   The role of this ligament is to provide dorsal stabilization to the scaphoid throughout the wrist movements.[23]

Figure 6: Ligaments of wrist [24]



ARTICULATIONS OF DISTAL RADIUS

1. **Distal Radio Ulnar Joint:**

DRUJ is formed from volar and dorsal radio ulnar ligaments and TFCC. Its primary role is the stabilization of the articulation of radius around the stationary ulna during pronation and supination. The ulnar head is located within the sigmoid notch of radius. The length of sigmoid notch increases from volar to dorsal.

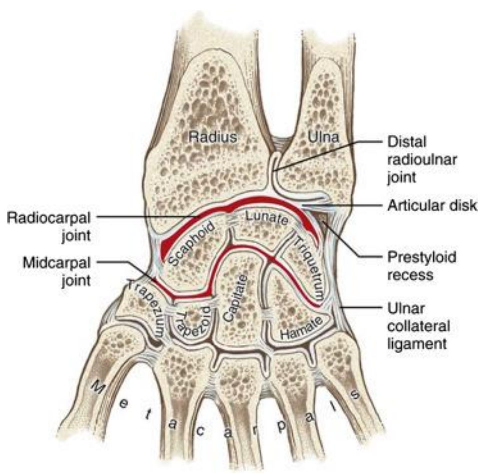
Distal radioulnar joint's obliquity was found to correlate with the ulnar variance. Patients with a typical negative ulnar variance, the sigmoid notch is found to be angled in a proximal-ulnar direction, but as ulnar variance became more positive, this became progressively less angled, eventually results in reverse obliquity.

During pronation, the dorsal radioulnar ligament becomes tight while the palmar radioulnar ligament becomes lax; during supination, the inverse occurs.[25]

2. **Radio carpal Joint:**

It is a synovial joint formed between radius, its articular disc and proximal carpal bones: scaphoid, lunate and triquetrum. The concave facet articulates with scaphoid and lunate while the articulation between radius and triquetrum is indirect and it is facilitated via articular disc.

Figure 7: Articulations of distal radius[26]



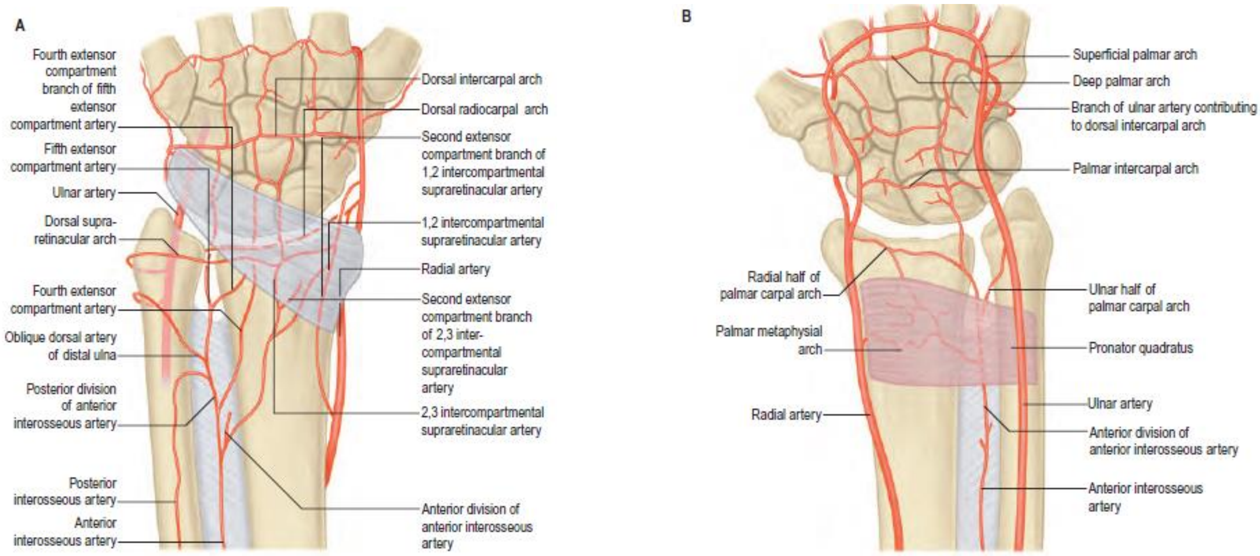
NEUROVASCULAR SUPPLY OF DISTAL RADIUS

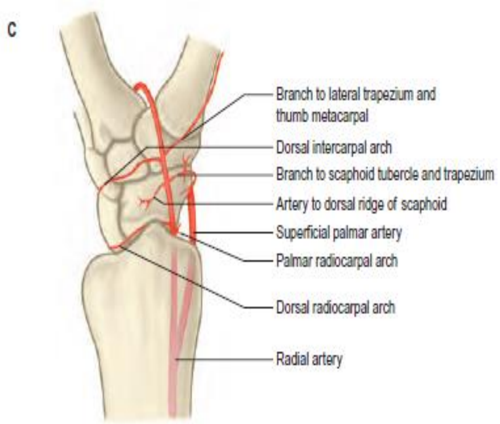
Vascularity of the distal forearm:

The articular disc and distal radio-ulnar joint is supplied by anterior interosseous artery through dorsal and palmar branches. They are often reinforced by the ulnar and posterior interosseous artery. Dorsal metaphysis of distal end radius is richly supplied by the branches that connect the anterior interosseous artery proximally to the dorsal carpal arch distally. These go through the fourth and fifth extensor compartments of the wrist and provide metaphyseal nutrient arteries. Intercompartmental vessels send nutrient arteries to radius bone through retinaculum between the first & second dorsal compartments, second & third dorsal compartments. These vessels arise from radial as well as anterior interosseous arteries to anastomose with dorsal palmar arch as depicted in the figure 8A, 8B and 8C.[27] The posterior and anterior interosseous nerves supply the wrist joint.

Figure 8A–C, The extraosseous blood supply to the distal end radius & ulna, the carpal bones [27]

(A)Dorsal aspect (B)Palmar aspect (C) Lateral aspect





RADIAL ARTERY:

At the wrist, it passes on the posterior aspect of the carpal bone between the tendons of APL, EPB and the lateral carpal ligament (Figure 9). It crosses the trapezium and scaphoid where again, its pulsation is obviously felt. When passing between head of the first dorsal interosseous, it is crossed by EPL tendon. In between the thumb extensors, the cephalic vein and radial nerve branches crosses the radial artery as shown in Figure 10. Sometimes, this artery gives a dorsal carpal superficial branch which crosses extensor tendons at the wrist. The lateral cutaneous forearm branches run along its distal part when it curves round the carpal bone.[28,29,30]

Figure 9: Radial artery[28]

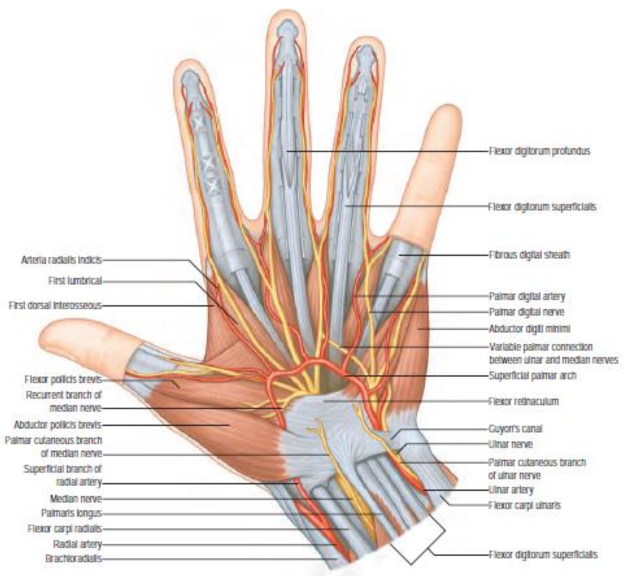
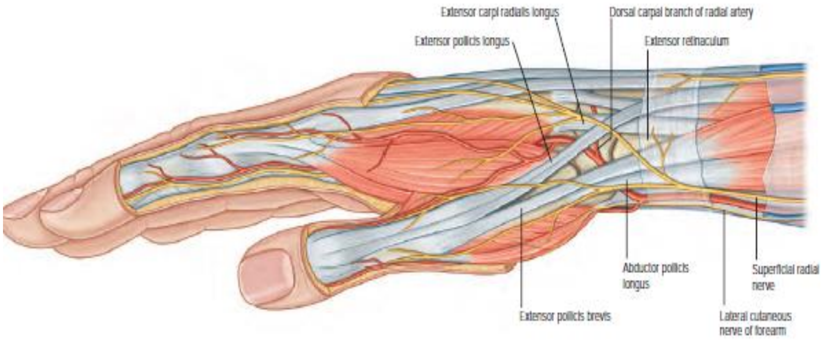


Figure 10: Dorsal carpal branch of radial artery [28]



Ulnar artery:

At the wrist, the ulnar artery is present underneath the superficial fascia and palmaris brevis tendon. It lies between the layers of flexor retinaculum. Ulnar artery is lateral to ulnar nerve and pisiform.[31]

Dorsal cutaneous branch:

Distally, a constant dorso-ulnar perforating vessel is given off. It arises 2 to 5 cm proximal to pisiform bone and courses along the dorsal branch of ulnar cutaneous nerve. This branch arises between tendons of extensor and flexor carpi ulnaris.[31]

Palmar carpal branch:

It crosses the distal third of ulna and lies deep to tendon of FDP and anastomoses with the palmar branch of the radial artery to make a palmar radiocarpal arch.[31]

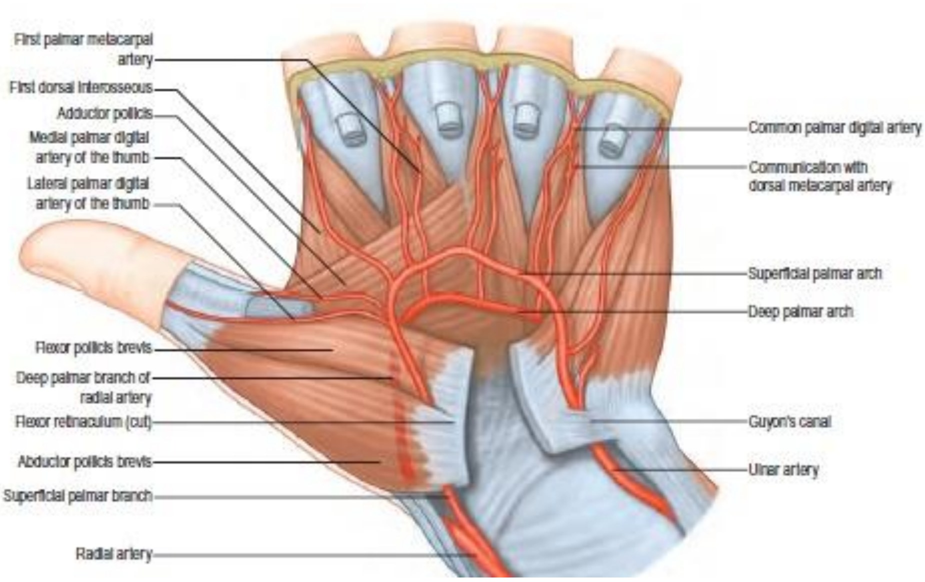
Dorsal carpal branch:

It originates proximal to the pisiform bone. It obliquely runs underneath the tendon of flexor carpi ulnaris in order to reach the carpal bone on dorsal side and it crosses radially beneath wrist extensor tendons. By anastomosing with the dorsal branch of the radial artery it completes the dorsal carpal palmar arch. At its origin, it gives off a small digital branch to run along the medial side of the 5th metacarpal bone and supplies the medial aspect of the 5th finger on the dorsal aspect.[31]

Deep palmar branch:

It is often double and passes between abductor and flexor digiti minimi tendon which is through or deep to the opponens digiti minimi anastomosing with radial artery to complete the deep palmar arch. It accompanies the deep branch of ulnar nerve as shown in Figure 11.

Figure- 11: Ulnar artery & palmar arch[31]



BIOMECHANICS OF WRIST JOINT:

Three Column Concept of Distal Forearm:

It is helpful for better understanding of patho-mechanism of fractures of wrist.

Radial column: Includes scaphoid fossa and radial styloid

Intermediate column: Includes sigmoid notch and lunate fossa

Ulnar column: Includes Distal ulna (DRUJ) with TFCC and ulnar styloid [32]

Figure 12: Three column concept of Distal Radius[33]

The radial styloid serves as a bone buttress and attachment point for extrinsic carpal ligaments, making it an important wrist stabilizer. Only a small amount of load is transmitted across the radial column under normal physiologic conditions. Along the intermediate column, a greater load is transmitted via the lunate fossa. In forearm rotation, the ulna is the most stable bone. The ligaments at the proximal radioulnar joint, distal radioulnar joint, and the interosseus membrane hold the ulna and radius together as they move around each other.

The TFCC helps in flexion/extension, radial/ulnar deviation and pronation/supination of the wrist joint. As a result, it is crucial in preserving the stability of the carpus or forearm. When creating a fist, significant forces are delivered across the ulnar column.

The distal radio ulnar joint has both rotational and translational components of motion. It does not have a single center of rotation. Four centers play a pivotal role in different positions of forearm rotation. They are

1. Dorsal radioulnar ligament
2. Palmar radioulnar ligament
3. Pronator Quadratus
4. Interosseus membrane

Fractures involving distal radio ulnar joint and distal radius change the biomechanics of TFCC. Incongruency of distal radio ulnar joint results in increasing dorsal tilt of distal radius.

The center of rotation for majority of wrist movements is considered to be located in proximal capitate. During extension and flexion majority of motion occurs in radio carpal joint, with some motion occurring through the midcarpal area. During radial to ulnar deviation, the proximal carpal row rotates dorsally and shifts radially at the midcarpal and the radiocarpal joints, with motion occurring at the radiocarpal and intercarpal joints. During ulnar to radial deviation, the proximal carpal row tends towards palmar rotation, with major motion occurring at the intercarpal joints. The proximal carpal row is considered to be an intercalated segment connecting forearm to hand where scaphoid acts as the stabilizer of the wrist.[34]

Wrist in neutral position and in forearm rotation, approximately 80% of force is transmitted through radiocarpal joint and the remaining 20% is across the ulnocarpal joint.[35] In radiocarpal joint analysis 45% is transmitted across the radioscaphoid joint and 35% across the radiolunate joint. The ulnocarpal force can be subdivided into across the ulnolunate (14%) and ulnotriquetral (8%). [36,37]

Movements of the wrist:

Wrist joint is an example for biaxial ellipsoidal joint. The movements at the wrist occurs in AP as well as in transverse axis. Wrist palmar and dorsi flexion affected through transverse axis. Radial and ulnar deviation AP axis. Circumduction of hand is by the combination of above stated movements along with supination and pronation of forearm.[38]

Radial and ulnar deviation are due to intercarpal and wrist joints movements. Normally, radial deviation is less than ulnar deviation. Contact of lunate bone with radial styloid during radial deviation along with ulnar collateral ligament restricts the radial deviation of the wrist.[39]

Table 1: Range of movements of wrist

Wrist range of movements	Normal range
Palmar flexion	$0\text{-}85^0$
Dorsiflexion	$0\text{-}85^0$
Abduction (radial deviation)	$0\text{-}20^0$
Abduction (ulna deviation)	$0\text{-}40^0$

Supination and pronation occur at forearm at proximal radio ulnar joint, interosseous membrane and distal radio ulnar joint.

Normal range:

- Supination: $0\text{-}90^0$
- Pronation: $0\text{-}90^0$

Flexor carpi ulnaris, flexor carpi radialis, extensor carpi ulnaris, extensor carpi radialis brevis and longus controls the wrist motion. Radiocarpal joint is a hinge joint but it is functionally similar to ball and socket joint.[40]

Muscles producing movements: [41]

Wrist palmar flexion is by

- Flexor carpi ulnaris
- Flexor carpi radialis

Wrist dorsiflexion is by

- Extensor carpi radialis brevis & longus
- Extensor carpi ulnaris

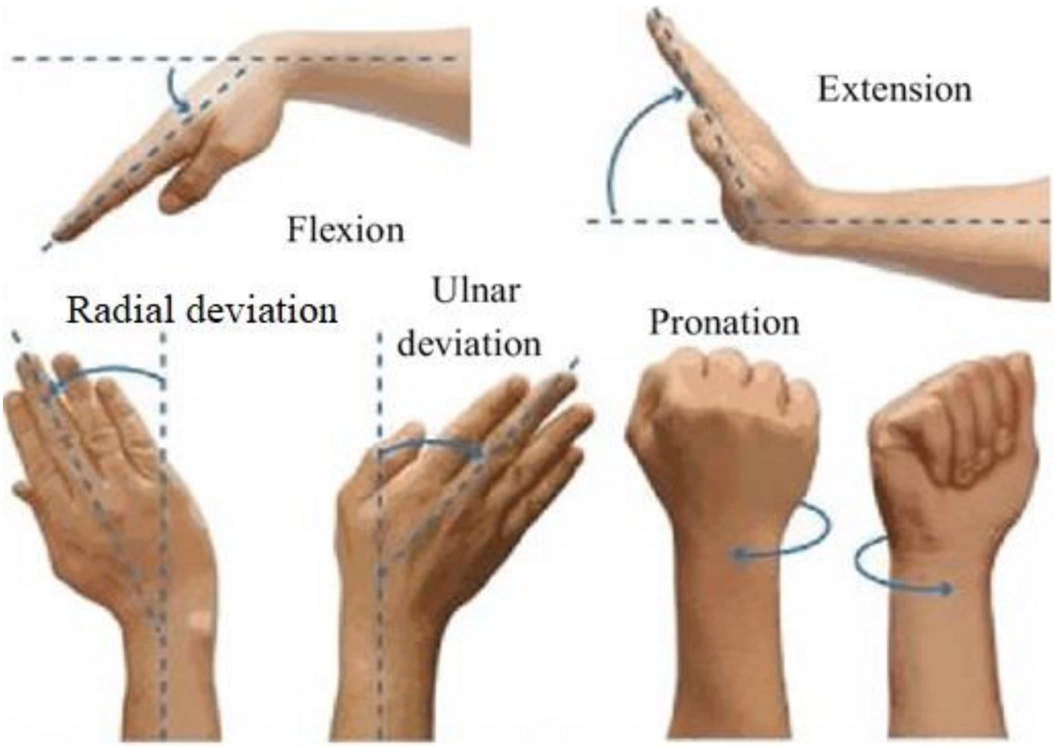
Ulnar deviation of the wrist is by

- Extensor carpi ulnaris
- Flexor carpi ulnaris

Radial deviation of the wrist is by

- Extensor carpi radialis brevis & longus
- Extensor pollicis brevis
- Flexor carpi radialis
- Abductor pollicis longus [42]

Figure 13: Movements of wrist joint [43]



MECHANISM OF INJURY:

The most common cause of fractures of distal radius is a fall on an outstretched hand with a hyperextended wrist.

Fractures happen when the wrist is in a dorsiflexion angle of 40 to 90 degrees, with less force required at smaller angles.

Three main postulates have been stated:

1. Theory of compression impaction
2. Avulsion theory
3. Incurvation theory.

Theory of Compression Impaction:

Bones of carpus are in touch with the impacted surface during wrist extension. In the meantime, radial head is compressing the humerus. The force is subsequently passed to radius's distal end. During this point that the fracture appears. The anterior portion is subjected to tensile forces, whereas the posterior part is subjected to compression forces. The forces of posterior restraint are extremely strong.[44]

Avulsion theory:

The indirect forces produced by the body weight are conveyed to the site of impact of the hand via the humerus, ulna, interosseous membrane, distal radius, and subsequently the volar wrist ligaments. The avulsion mechanism implemented by the tensile forces is conveyed by the volar ligaments of wrist causes the distal radius fracture.[44]

Incurvation theory:

Bending forces, according to this idea, cause fractures. Three factors influence the fracture line:

1. Hand position
2. Impact region's extent
3. Quantity of the applied force.

There have been two mechanisms postulated:

Axial stress on the radius is caused by a rearward fall on the palm, extended wrist, and without displacement of body over the hand. Compression forces over the volar cortex and tensile forces on the dorsal are sustained by the radial incurved 'girder.'

Forced flexion is a condition in which the carpus exerts direct tension on the volar region of the radial joint while the dorsal ligaments provide traction. This is the polar opposite of the mechanism described for dorsally displaced fractures, and it occurs frequently in motorcycle accidents.

FACTORS RESPONSIBLE FOR EACH TYPE OF FRACTURE:

A. NATURE OF FORCE:

Magnitude of Force:

An ordinary fall from height produces very different forces than a high-velocity impact from a motorcycle accident or a fall from a high vantage point. The inertia of the body or vehicle, as well as its varied accelerations, should be considered in these situations. The latter can be determined using the formula below: the closer the force relationship to the contact area plane, the lower the compression forces will be. The sheer component of the forces, on the other hand, increases.

Direction of the Force:

Compression forces are the principal components of a force applied perpendicular to the contact region across the bone axis. The lower the compression pressures, the more angled the force is in relation to the contact area plane. The sheer component of forces, on the contrary, increases.

Speed of application of the force:

A force delivered in tenths of a second (high-speed automobile collision) does not allow muscle contraction to resist it; on the contrary, a slow and progressive injury (a fall from standing height) permits muscle contraction to resist the forces applied to the hand. Forces with relation to the effect situation: The components of a force applied at the metacarpal heads differ from those applied at the base of the palm, where axial forces via the radius are predominate.

B. HAND AND WRIST POSITIONS:

The pattern of fracture lines is influenced by the wrist and hand postures relative to the body during injury. Depending on the location of the body in relation to the hand, wrist extension can cause posterior or anterior displacement.

AGE OF THE PATIENT:

The age of patient is crucial in determining the bone, ligamentous, and muscular structural properties; in older adults, a fall from standing height frequently results in a comminuted fracture with bone disintegration. In young people, sprains are more common, with comminuted fractures occurring only after significant injuries.[45]

C. BONE MORPHOLOGY:

In lateral view, the distal end of radius seems to be a cup with an anterior angulation of 10°, which illustrates why the posterior region of radius is subjected to higher stress than that of the anterior. This also explains why fractures with posterior displacement are so common. Distal radius has a radial inclination of 25° when viewed from the PA view. This explains the occurrence of radial displacements in the presence of a radial styloid fragment, which is occasionally found alone. It has a volar angulation from the lateral view.

D. MUSCULAR CONTRACTION DURING INJURY:

The outcome of forces exerted is altered by the muscular contraction. Considering the impact of a shock on the metacarpal heads, leads to forceful wrist extension without muscle contraction. The passive bone and ligamentous constraints achieve a static state of balance in this situation. At radius, the force applied can be separated into anterior tensile forces and posterior compression forces. A posteriorly displaced force which is extra articular will arise as a consequence of above. The wrist will be in a dynamic balance of forces if a volar muscular contraction force is introduced. This force, which is caused by flexor muscle contractions, may decrease anterior tensile forces and possibly increase compression forces, modifying the final outcome in an axial compression to create a fracture which is intra-articular.

MECHANISM OF INJURY IN VOLAR BARTON FRACTURES:

Barton's fracture occurs as a result of compression injury with a marginal shearing force on the distal radius. Most common mode of injury is fall on an outstretched hand with a pronated wrist which is outstretched. The compressive type of force will pass from the hand through the radius articular surface.[46,47] It will result in dorsiflexion stress and tension failure of volar lip of radius. Thus, strong volar radiocarpal ligaments will avulse the volar lip of the radius from the metaphysis.

CLASSIFICATION OF FRACTURES:

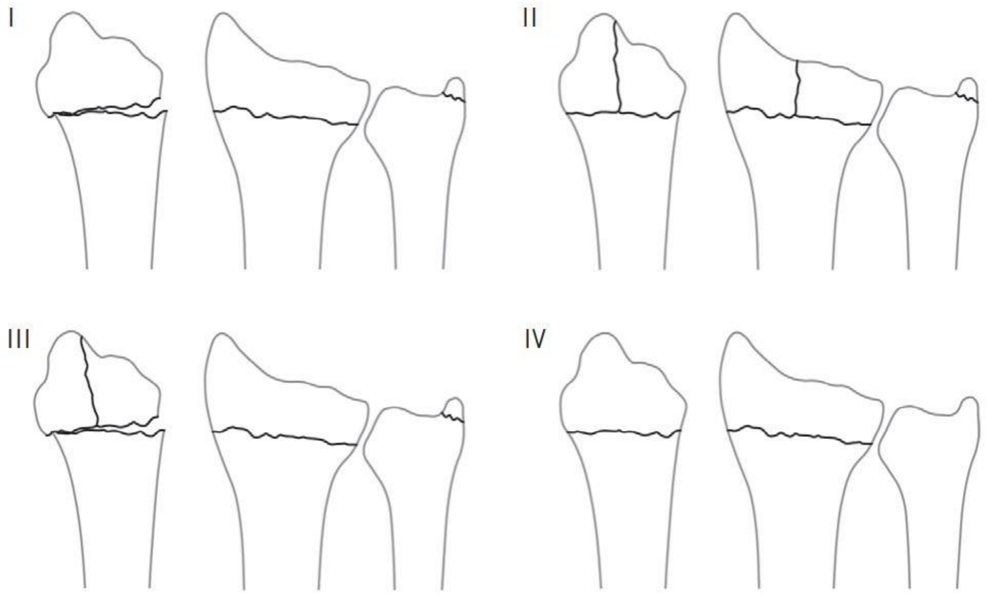
Many classifications have been proposed for the classification of distal radius fractures, most of which are based on morphology, nature of displacement, comminution and articular involvement.

Gartland and Werley classification (1951):

Table 2: Gartland and Werley classification[48]

TYPE	PATTERN
Type 1	Extra-articular; Displaced
Type 2	Intra-articular; Non displaced
Type 3	Intra-articular; Displaced
Type 4	Extra-articular; Non displaced (Added by Sologaard and Sarmiento)

Figure 14: Gartland and Werley classification[49]



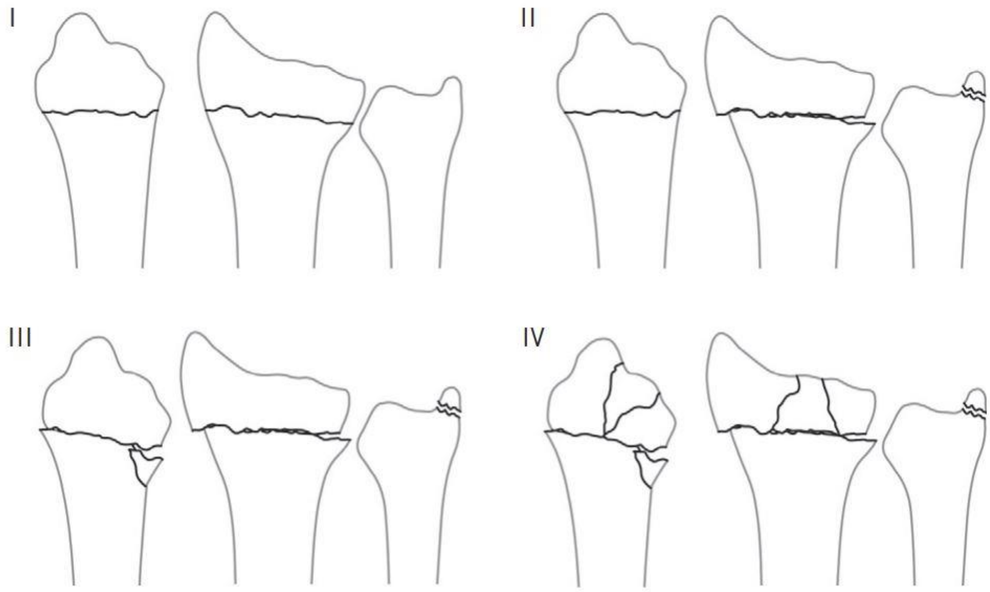
Older classification (1965):

In 1965, Older and his colleagues published a four-part classification for extra articular Colle's fracture. But it was later modified by Solgaard in 1984 according to dorsal angulation degree, extent of metaphyseal comminution and the extent and direction of displacement[50].

Table 3: Older classification[49]

TYPE	PATTERN
Type 1	Dorsal angulation ≤ 5 degrees; Length of radial styloid ≥ 7mm
Type 2	Dorsal angulation > 5 degrees; Length of radial styloid < 7mm and ≥ 1mm
Type 3	Dorsal angulation > 5 degrees; Length of radial styloid ≤ 4mm and slight dorsal comminution
Type 4	Dorsal angulation > 5 degrees, length of radial styloid usually negative, comminution; intra-articular involvement

Figure 15: Older classification[49]



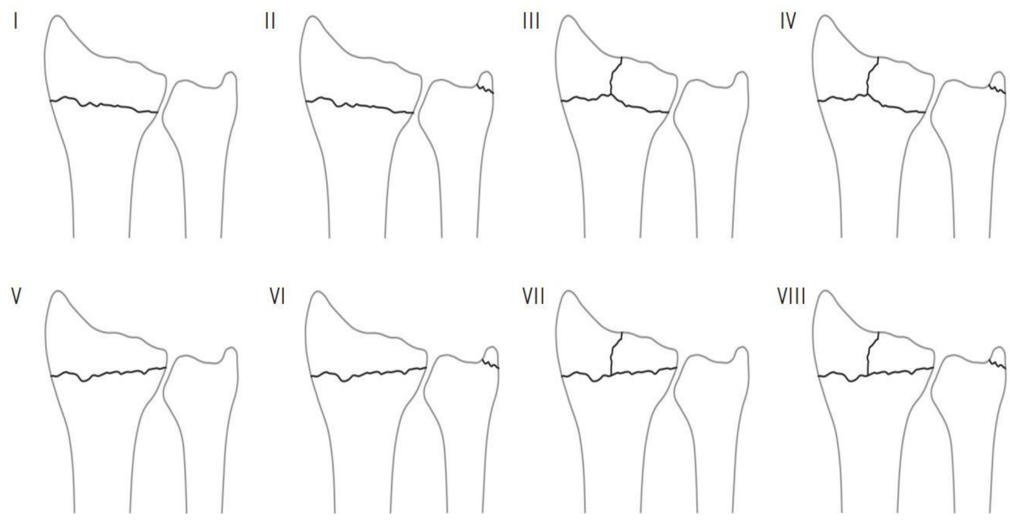
FRYKMAN CLASSIFICATION (1967):

Frykman identified the importance of ulna styloid fractures. His classification identifies the radioulnar and radiocarpal joint involvement as well as the ulnar styloid fracture. It is a simple system with eight divisions with four main types of injuries.[51]

Table 4: Frykman classification[51]

FRACTURE PATTERN	DISTAL ULNA FRACTURE ABSENT	DISTAL ULNA FRACTURE PRESENT
Extra articular	Type 1	Type 2
Intra articular		
Radiocarpal joint involvement	Type 3	Type 4
DRUJ involvement	Type 5	Type 6
Radiocarpal and DRUJ involvement	Type 7	Type 8

Figure 16: Frykman classification [51,52]



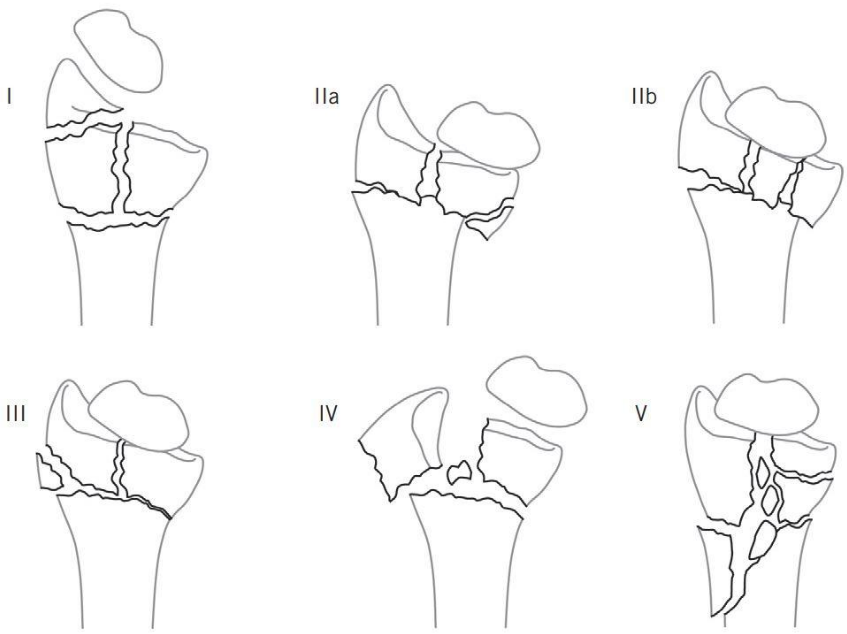
MELONE CLASSIFICATION (1984):

It classifies the intra articular fracture patterns of the distal radius. It is based on the observation that there are four components to radiocarpal articular injuries: the radial shaft, radial styloid, dorsal medial fragment of lunate facet and palmar medial fragment of lunate facet. These components are resulted from the impaction of lunate on distal radius during injury. [53]

Table 5: Melone classification[54]

TYPE	PATTERN
Type 1	Undisplaced; No or minimal comminution
Type 2	"Die punch fracture" with moderate or severe displacement Type 2a: Reducible; Type 2b: Irreducible
Type 3	Spike fragment present
Type 4	Wide separation of intra articular fragments
Type 5	Explosion fracture with severe comminution

Figure 17: Melone classification [54]



AO CLASSIFICATION (1990):

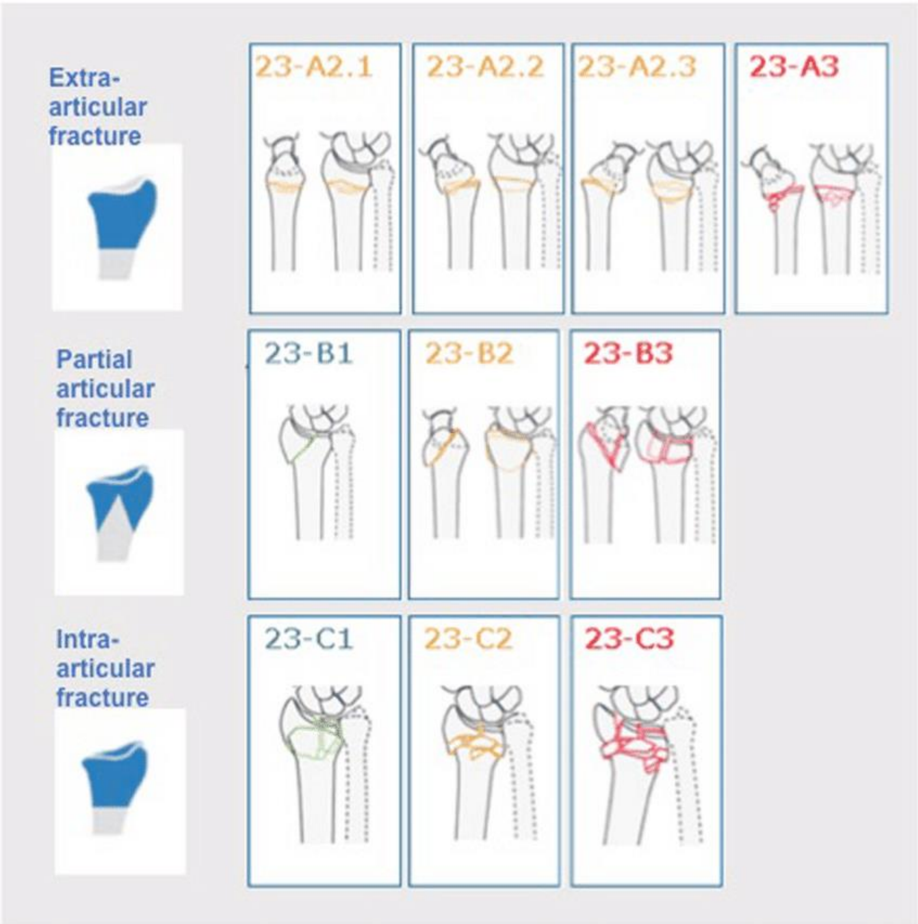
AO classification was originally described in 1990[55] which was adopted by Orthopedic Trauma Association to become AO/OTA classification in 2007. This is the most widely used system for classification in current studies. It has three main fracture groups which are further divided into 27 possible patterns to describe the morphology and the fracture location. They are classified as

AO A – Extra articular

AO B – Partial articular

AO C – Complete articular; Within these there are three groups, each further divided into subtypes based on direction of displacement and comminution

Figure 18: AO classification[56]



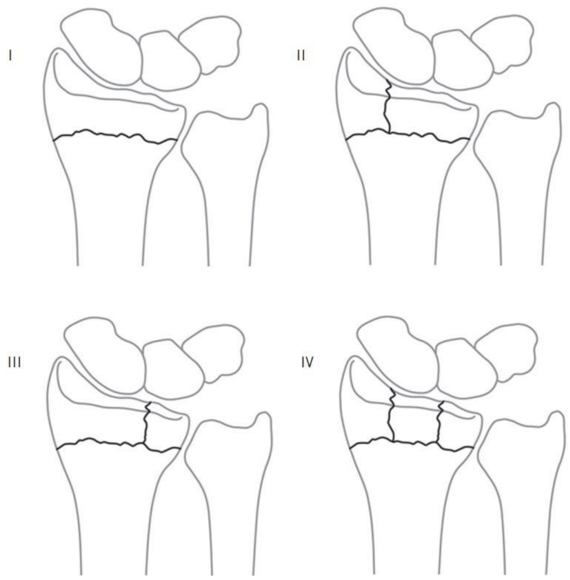
MAYO CLASSIFICATION (1992):

It was proposed by Mayo clinic in 1992. It is similar to Frykman classification and it focuses on the extension of fracture line into radiocarpal or radioulnar joint.[57] It also distinguishes between radioscaphoid and radiolunate joint surface involvement but it does not emphasize on involvement of Ulna.

Table 6: Mayo classification[58]

TYPE	PATTERN
Type 1	Extra articular with Radiocarpal involvement or Undisplaced intraarticular
Type 2	Intraarticular, displaced with significant involvement of articular surface
Type 3	Intra-articular, displaced, often presents as 'die punch' fracture of lunate fossa
Type 4	Intra-articular, displaced, involving both radioscaphoid joint surfaces and usually sigmoid fossa of distal radioulnar joint

Figure 19: Mayo classification [58]



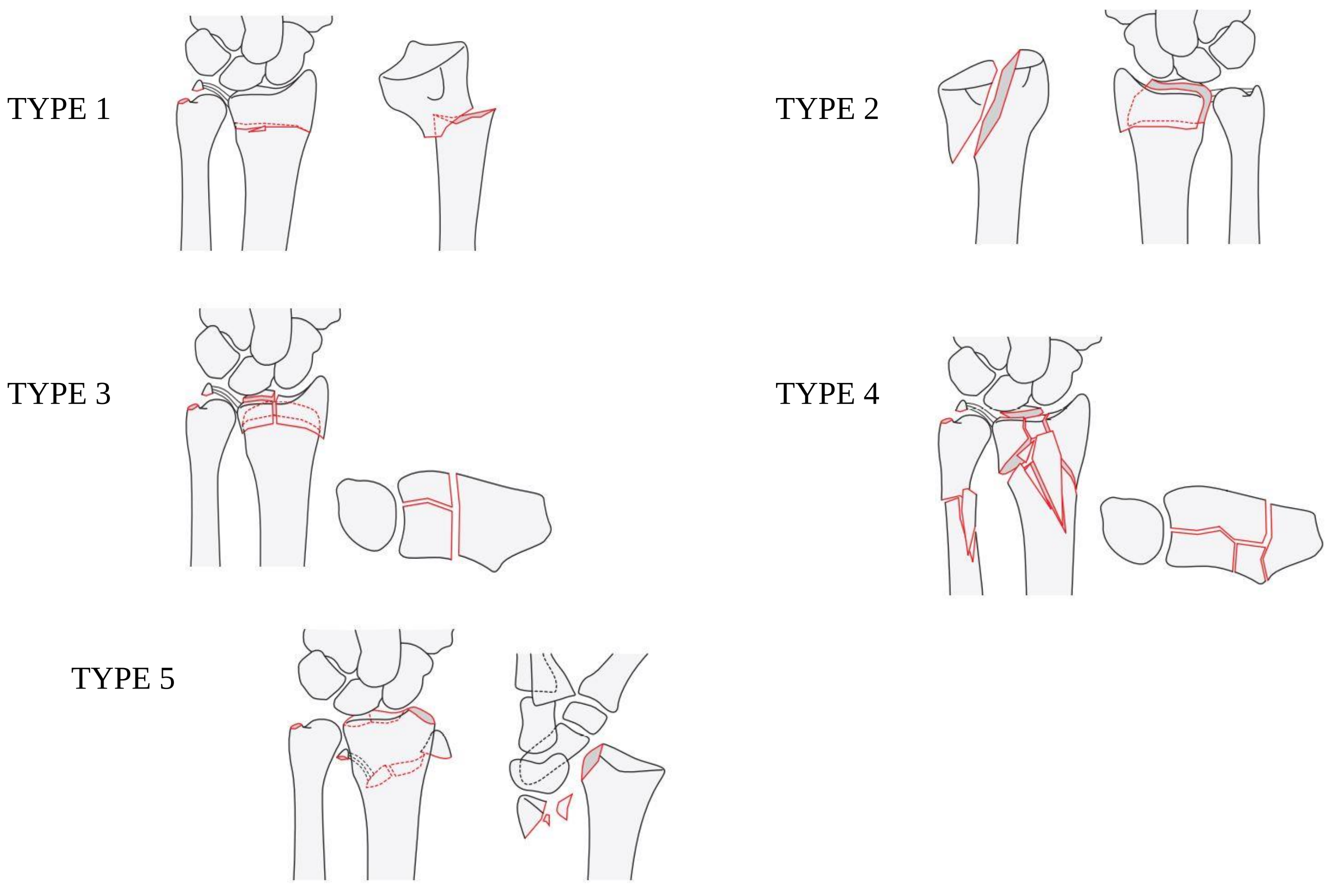
FERNANDEZ CLASSIFICATION (1993):

The more recent one was by Fernandez where he classified distal radius fractures according to the injury mechanism. It was thought to provide a better understanding regarding the soft tissue injury thus helping in better assessment [59].

Table 7: Fernandez classification [59]

TYPE	MECHANISM OF INJURY
Type 1	Bending of the metaphysis
Type 2	Shearing fractures of joint surface
Type 3	Compression of the joint surface
Type 4	Avulsion or Radiocarpal fracture dislocations
Type 5	Combined fractures with high velocity injuries

Figure 20: Fernandez classification [58]



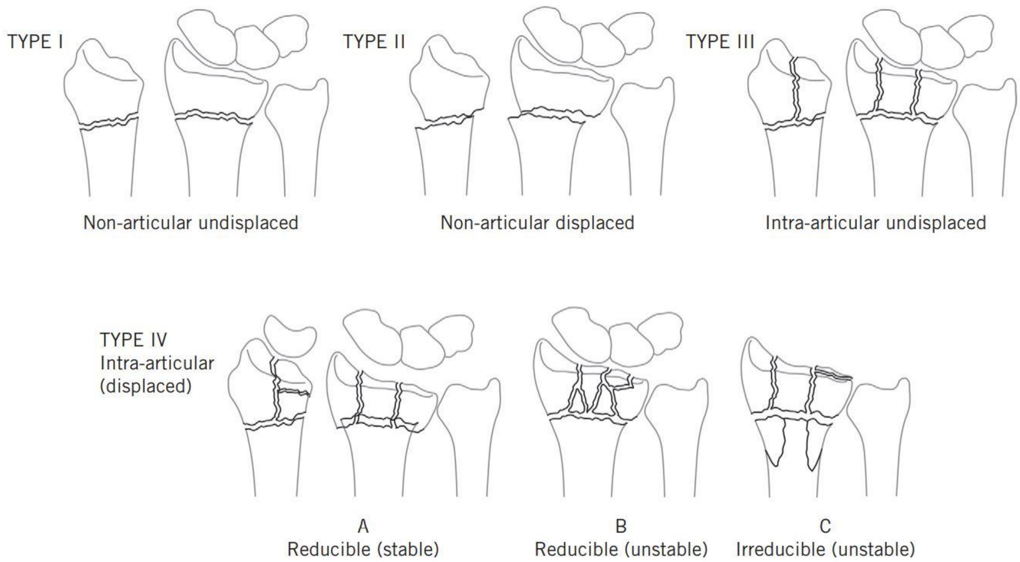
UNIVERSAL CLASSIFICATION (1993):

This classification was initially proposed by Rayhack but was later refined by Conney in 1993. It was actually attempted to improve the Frykman classification to make a difference between displaced and non-displaced intra articular fractures.[60]

Table 8: Universal classification [60]

TYPE	PATTERN
Type 1	Non articular undisplaced
Type 2	Non articular displaced
Type 3	Intra-articular undisplaced
Type 4	Intra articular displaced
	A – Reducible and stable
	B – Reducible and unstable
	C – Irreducible and unstable

Figure 21: Universal classification [58]



Sir Abraham Colles discovered the fractures of distal radius first in 1814 and named it as Colle’s fracture which lacked the typical feature of fracture like crepitus at the fracture site and abnormal motility. Proper reduction was essential or else there was a tendency for recurrence of deformity. He noted that “one consolation remains, that the fractured wrist / limb at some remote period will again enjoy its freedom in all its motions and was completely exempt from pain”. [61]

In 1986, Maurizio [62] and colleagues in a follow up study on long term results of the conservative treatment of distal radius fractures involving 297 cases, observed that there were excellent results in 38%, good in 49%, fair in 11.5%, and poor in 1.5% cases. Hand grip strength was reduced but restriction of the wrist range of movements was not reduced. Median nerve neuropathy was commonly seen. The values of radial deviation, volar tilt and radio-ulnar index were inconsistent compared to normal values. They observed loss of reduction when compared with post reduction and follow-up radiograms. They concluded that fractures of distal radius are not easy to treat and long-term results following conservative management may not be as acceptable as it was generally assumed to be.

A study conducted by A.K. Mehra et al [63] in 1993 where they have treated 82 patients with Volar Barton fracture with an incidence of 10.6 percent of cases of distal radius fractures. They also classified Barton fracture into 3 types; Type 1- Fracture with large and single displaced fragment. Type 2 – Displaced and Comminuted fracture with small or large fragments and Type 3 - fractures with a large displaced fragment and below the displaced fragment lies the additional small cortical fragment.

A study conducted by A B Zoubos et al [64] from 1985-1994 where they have managed 35 patients with Volar Barton fracture. All the fractures were managed with small buttress plates and screws. 23 patients had excellent results, 10 patients had good results and 2 patients had fair results.

A study conducted by AK Aggarwal and ON Nagi in 2004 [65] in Chandigarh stated that internal fixation by open reduction of Volar Barton fracture can restore articular congruity and resulted in good to excellent function. Fracture was healed in 7 to 10 weeks postoperatively. Excellent results were seen in 9 out of 16 patients, good outcome in 5 patients and fair in remaining 2 patients. Postoperative radiograph showed a mean volar angle of 8.3°, mean ulnar angle of 20.7°.

A study conducted in 2005 by Wong KK, Chan KW, Kwok TK, Mak KH [66] in Hong Kong where the evaluation of the functional and radiological results of unstable fractures of distal radius treated with volar locking plate has been made. The mean age of the patients was 58.6 years. Out of 30 patients, 24 patients had excellent outcome, 5 patients had good outcome and 1 patient had fair outcome. Post operative radiological assessment showed mean volar angulation of 5°, mean radial inclination of 22° and mean radial shortening of 0.1 mm. They also stated that dorsal plate fixation is biomechanically effective in buttressing a dorsally displaced fracture of distal radius.

A study conducted in 2005 in Keelung [67] where 23 volar Barton fractures were managed with either plating or pinning. All the fractures healed within 3 months and the union rate was 100%. Postoperatively the mean radio ulnar variance was minus 1.3 mm in plating group and minus 0.9 mm in K wire group. At the final follow-up, results from the plating group were superior to the pinning group.

Santagio A Lozano Calderon, Job Doornberg, David Ring [68] conducted in 2005 where 20 patients with dorsal Barton fracture were evaluated. All the patients underwent surgical reconstruction of the articular surface with dorsal buttressing plate. The final average amount of wrist motion was 59 degrees of flexion, 56 degrees of extension, 87 degrees of pronation and 85 degrees of supination. 18 patients had excellent outcome and 2 patients had fair outcome.

In the year 2007, Zoltan et al.,[69] observed the long-term outcome after non surgically managed distal radius fractures which included recovery of hand grip strength, wrist mobility and radiological parameters. Eighty-seven patients with mean age 55 years treated with closed reduction and casting, were evaluated radiographically as well as clinically during the first 6 months and finally after 9-13 years. Fifty patients had extra-articular fractures (AO Class A), 4 had simple intra-articular fractures (AO Class B) and 33 had complete intra-articular fractures (AO Class C). Their data indicated that, few patients with nonsurgical management of distal radius fractures witnessed some sort of wrist and hand impairment even after a decade following the trauma. They concluded that fracture class according to AO classification was not correlating to the outcome, whereas severity of initial fracture influenced that clinical outcome. Patients with poor outcome had sustained moderate to severe displaced fractures which also healed with greater displacement. They also observed that recovery of range of motion was faster than the grip strength. Young patients recover faster than elderly.

LIAO Qian-de et al [70] conducted in 2008 where clinical efficacy of volar Barton fracture fixed with T type titanium plate was evaluated. 18 patients were evaluated in this study. Excellent outcome was noted in 12 patients, good outcome in 5 patients and fair outcome in 1 patient. The mean volar tilt in the postoperative radiograph was 11°, ulnar inclining angle was 22.4°.

Wen Jie Tang[71] and his colleagues conducted in 2008 in China where 23 cases of volar Barton fracture were managed by conservative method. At the final follow up 11 patients had satisfactory outcome and 12 patients had unsatisfactory outcome. They also stated that the step on the articular surface should be less than 2mm after reduction for a better outcome. Non operative method of management is recommended if the fractures are not associated with subluxation of the carpus.

In the year 2009, P Lakshmanan, MK Sayana, B Purushothaman, JL Sher [72] conducted a study in United Kingdom tried to establish a consensus regarding immobilisation of wrist following Barton fractures and paediatric distal end radius fractures. In case of volar Barton fractures, 53% of orthopaedic surgeons immobilised the wrist in dorsiflexion, 20% immobilised the wrist in palmar flexion. In case of dorsal Barton fractures, 48% immobilised the wrist in palmar flexion and 25% immobilised the wrist in dorsiflexion. They suggested that dorsal Barton fracture must be immobilised in dorsi flexion as a volar flexed wrist relaxes the intact volar carpal ligaments, resulting in subluxation of the wrist with the fractured dorsal lip of the distal radius.

In 2012, a study conducted by Ranjit shaw et al [73] in India where 26 patients of volar Barton fracture were managed with volar locking plate. All the fractures healed with a mean period of 9.3 weeks. The wrist function was satisfactory in 90% of cases. They concluded that locking plates have a better efficacy in terms of immediate stability, maintaining anatomic reduction and early mobilisation.

A study conducted in China by the year by Tang et al [6] in 2012, where comparison was made in 33 patients with volar Barton fracture fixed with volar anatomical plate and volar locking plate. They concluded that both anatomical and locking plate provide satisfactory results but the locking plates provide better functional outcome.

Shah H, Chavali V, Daveshwar R [74] conducted in 2015 in India, where volar Barton fractures in adolescent age group fixed with volar plate using the buttress principle were assessed. In this study screws were not inserted in the distal fragment. They concluded that buttress plating in the adolescent age group is an excellent technique to achieve satisfactory outcome without violation of the physis.

Yi lu et al [75] during the year 2015, in China proposed the classification based on morphology and grading system for volar Barton fractures. They classified Barton fractures into four types as typical Barton, ulnar Barton, radial Barton and comminuted Barton. They also graded the fracture into two types as simple split and split depression. The distribution of typical, ulna, radial and comminuted Barton type fractures was 69 %, 7 %, 5 % and 19 %, respectively. Grade 2 fractures accounted for 49 % in their series.

Yoichi Sugiyama et al [76] conducted a study in Japan in 2016 where 10 cases of distal radius fractures accompanied by intra articular volar displaced fragments were surgically treated with volar locking plate. During the final follow up, the mean range of motion of wrist joint was 73° of extension, 77° of extension, 86° of pronation and 85° of supination. The functional outcome was excellent in all the patients.

By 2017, a study conducted by Roshan et al [77] in Karnataka, India where they have evaluated the clinical and functional outcome of unstable distal radius fractures treated with fixed angle locking plate. 42 patients were analysed with a mean age of 47.6 years. At the final follow up, the mean grip strength was 82% of the unaffected wrist. The mean volar tilt was 5.4°, radial inclination was 19.2°, radial shortening was 0.8mm. 3 patients had extensor tenosynovitis and 2 patients had angular instability.

In Gujarat, by the year 2018, Kushal Parikh, Nishant Chaudhari, Mitesh Patel and Dhwanil Tada [78] conducted a study in which they evaluated the functional outcome of internal fixation by open reduction with volar plating in reverse Barton’s fracture of distal radius. 43 patients were evaluated in this study. Functional outcome was excellent in 29 patients, good in 11 patients and fair in 3 patients. They also stated that anatomical reduction and early mobilisation improved the outcome significantly.

In 2019, a study conducted by Abhiram R. Bhashyam et al [79] in USA stated that dorsal Barton fractures might be the variants of dorsal radio carpal subluxation. Since both were high energy injuries and associated with instability.

Michael C. Daly, Taylor A. Horst and Chaitanya S Mudgal [80] conducted a study in 2019 in USA. They stated that 75% of patients with volar Barton fracture had a dorsal cortical break. Dorsal cortical breaks were not associated with age or gender, suggesting these fractures might not be associated with osteoporosis.

In 2019, a study conducted in China by S S Li et al [81] stated that the peak age of adult Barton fracture is from 51 to 60 years with more female patients than the male.

In 2019, a study was conducted by Soo Min Cha and Hyun Dae Shin [82] in Korea. In that study 9 patients of paediatric age group with Salter Harris type II distal radius fractures in sagittal plane were included. All the patients were treated with buttress plating. The radiological parameters of the affected side after surgery were comparable with the contralateral side. The mean flexion-extension arc was 140.56°, mean pronation-supination arc was 165° and the mean grip strength was 26.67 kg.

In 2020, Vikram Goud and Manoj Kanamarlapudi [83] conducted a study in Hyderabad. Radiological and functional outcomes of 30 cases of volar Barton fracture fixed with open reduction and internal fixation by plate were evaluated. All fractures were healed within a period of 7 weeks. Dominant wrist is involved in majority of cases. More patients were in the age group of 41-50 years. They stated that all the patients had a good functional outcome even though the radiological outcome is fair or poor.

IMAGING TECHNIQUES OF DISTAL RADIUS FRACTURES:

In case of suspecting distal radius fractures, the standard radiological views such as Anteroposterior (AP) view and Lateral view can be performed. For assessment of associated injuries, additional views might be performed.

A number of radiologic measurements quantifying the orientation of the distal radius are in common use and it is critical to comprehend these in order to reduce interobserver error.

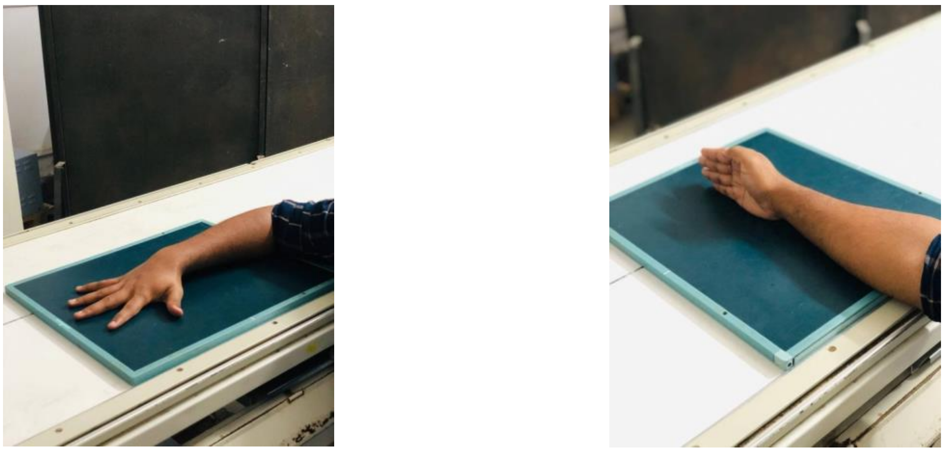
X ray imaging:

Posteroanterior (PA) and lateral views are the routine views obtained while assessing a distal radius fracture. The orientation of the beam, position of wrist, forearm and arm also affects the bony landmarks appearance, which might affect the accuracy of the measurements.

The standard method to obtain a PA radiograph is shoulder in 90 degrees abduction, elbow in 90 degrees flexion with forearm and neutral wrist.

For the lateral view the shoulder should be adducted and elbow is placed in 90 degrees of flexion with the hand placed in the similar plane as the humerus.[84,85]

Figure 22: Positioning of Wrist for PA view ; Lateral view



Radial height:

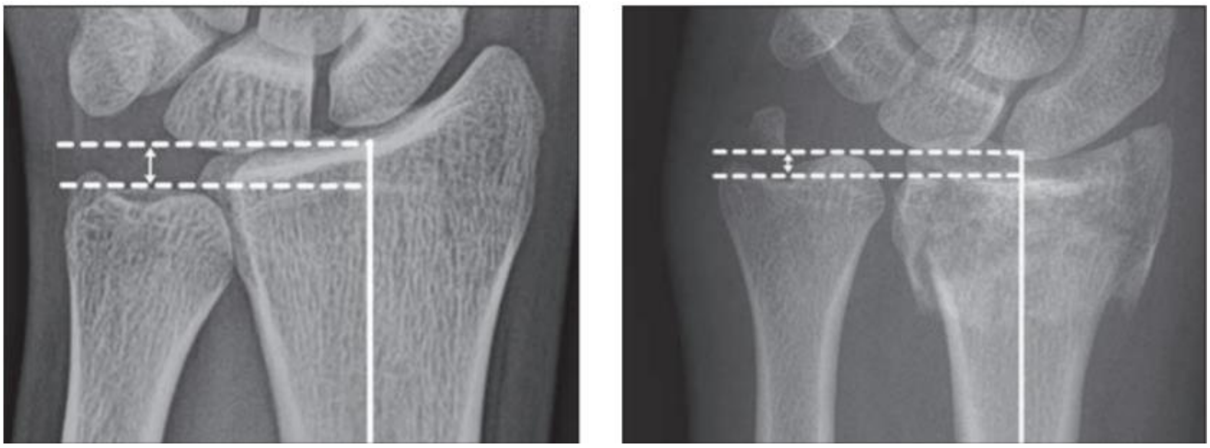
It is calculated on the PA radiograph. It refers to the distance between a line drawn tangential to the tip of the radial styloid and tangential to the most distal part of the ulnar head. [86]

Figure 23: Radial height (normal:8 to 18 mm) [87,88,89]

Ulnar variance:

It is also measured in PA view. It measures the vertical distance between the two lines perpendicular to long axis of the radius. It measures the radial length, with emphasis on its effect on the Distal radio ulnar joint (DRUJ)[86].

Figure 24: (A) Ulnar negative variance (B) Ulnar positive variance [90]



Radial inclination:

It is the measurement made on the PA view. It is the angle made by the line which is drawn from the tip of the radial styloid to the medial edge of the articular side of the radius and a perpendicular line drawn to the long axis of the shaft of radius.[86]

Figure 25: Radial inclination (normal: 12 to 25 degrees) [88,89,90]

Doral / Palmar tilt:

It is measured on the lateral radiograph. A line is drawn between the most distal point volar and dorsal lips of distal radius. Dorsal/ Palmar tilt is the angle measured the former line and the line drawn perpendicular to the long axis of the radius.[86]

Figure 26: Dorsal/ Palmar tilt (normal: 0 to 25 degrees) [87,88,89]

Carpal alignment:

The deformity of the distal radius is compensated by the malalignment of the carpus and it should not be confused with the carpal instability. The lunate tilts in the same direction with the dorsal or palmar tilt of the distal radius. At the mid carpal joint, with flexion of the carpal row which is distal in dorsal deformity or extension in palmar deformity, the carpus will get adapted without any carpal ligament disruption.

To measure the carpal malalignment, two lines are drawn on the lateral view, one along the long axis of the capitate and one along the long axis of the radius [91]. If the lines are not intersected with the carpus, then it is misaligned.

Tear drop angle and Antero posterior distance:

It is measured on a lateral radiograph.[92] The teardrop of the distal radius articular surface refers to the U-shaped outline of the volar rim of facet of lunate. The tear drop angle refers to the angle between the central axis of the tear drop and the central axis of the radial shaft which is normally 70 degrees.

Tear drop angle which is depressed may be the only evidence that the reduction is incomplete and the articular incongruity still persists. [86]

Figure 27: (A) Normal tear drop angle (B) Abnormal tear drop angle [90]

Antero posterior distance is the distance formed between the apices of the volar and dorsal rims of the lunate facet.

Computerized Tomography:

Computerized Tomography (CT) is used to improve the visualization and accuracy of the articular fractures of distal radius. CT demonstrates the intra articular fracture lines and measures intra articular displacement more accurately than the plain radiographs. It also demonstrates the presence of sigmoid notch fractures more accurately than the plain radiographs.

Three-dimensional CT imaging provides a better imaging to assess the intra articular fractures of distal radius. It also reveals the coronal plane fracture lines, articular comminution and central articular depression which may influence the treatment.

Brink and D.A. Rikli [93] in their study suggested the four-corner concept, a CT based assessment of distal radius fractures.

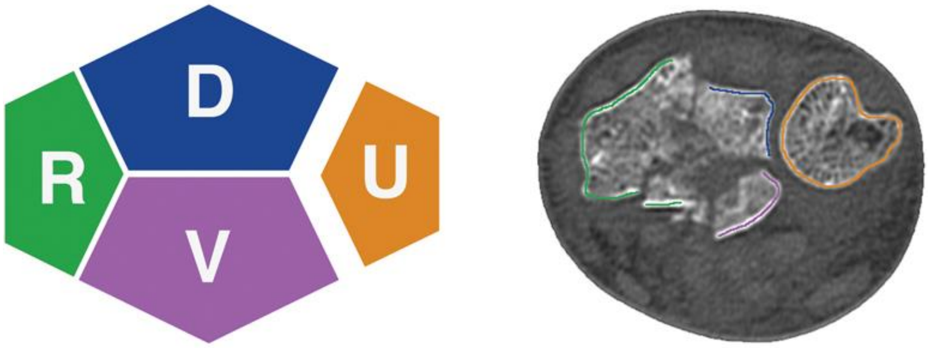
Radial corner – Responsible for radio carpal stability and it is formed by radial styloid and the scaphoid fossa.

Ulna corner – Consists of either ulnar head or ulnar styloid and it is responsible for the stability of DRUJ.

Volar corner – Cortical bone is thicker in this corner hence comminution is rarely seen. If the buttress of this fragment is lost due to cortical comminution, reduction and fixation is mandatory.

Dorsal corner – If the fragment is displaced and substantial, it should be restored specifically.

Figure 28: Four corner concept in axial CT [93]



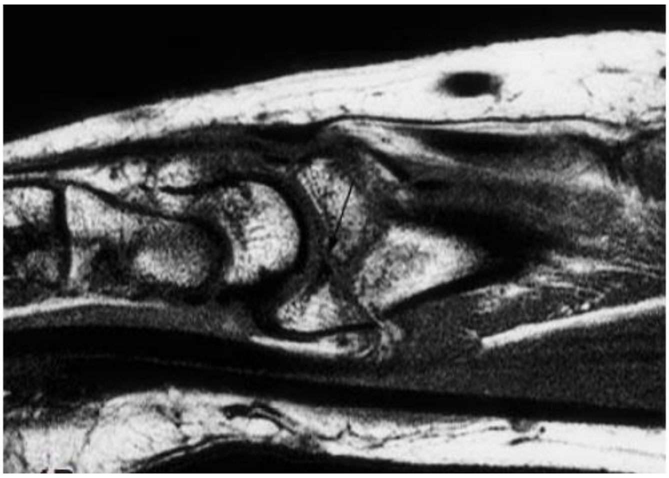
Magnetic Resonance Imaging:

It is used to diagnose the bony, soft tissue and ligamentous abnormalities that are associated with the distal radius fractures. It also detects injury to the flexor and extensor tendons or the damage to the median nerve. It is also used in the early diagnosis of the associated scaphoid or lunate fractures. Injuries to TFCC are most commonly associated with 45-66% of the fractures of distal radius. Conventional radiograph won't help in the diagnosis of TFCC injury unless there is either wide diastasis of DRUJ. Its evaluation can be done only by arthrography, arthroscopy and MRI. [94]

Figure 29: MRI Imaging of distal radius fractures

(A) Coronal image showing a comminuted impaction fracture of the distal radius, with intra-articular extension to the junction of the scaphoid and lunate facets (B) Sagittal image shows impaction, and intra-articular extension (arrow) with neutral angulation [94]

29 (A) **29 (B)**



PRINCIPLES OF MANAGEMENT:

La fontine et al [95] classified the following factors as the predictors of instability

1. Initial dorsal angulation > 20° (Volar tilt)
2. Metaphyseal comminution on dorsal aspect
3. Involvement of the dorsal surface
4. Associated ulna fracture
5. Age > 60 years

Table 9: Radiographic criteria for the acceptable reduction of distal radius fractures [96]

Criterion	*Normal*	*Acceptable*
Ulnar variance	±2 mm comparing level of lunate facet to ulnar head	No more than 2 mm of shortening relative to ulnar head
Radial height	12mm	
Palmar tilt	11 degrees of volar tilt	Neutral
Radial inclination	20 degrees as measured from lunate fact from ulnar styloid	No less than 10 degrees
Intra articular step/gap	None	Less than 2mm of either

Goldwyn et al [97] suggested that traction radiographs help in decision making in treatment plans. Number of factors should be considered for the development of treatment plan such as characteristics of initial injury, alignment after reducing the fracture, age of the patient, quality of bone, demand of the patient and the outcome expected. If closed treatment is chosen for a patient with stability questionable, close monitoring should be advised.

The original principles of AO fracture fixation [98] were

1. Anatomic fracture reduction and fixation
2. Fracture fixation providing absolute or relative stability
3. Preservation of blood supply
4. Early and safe mobilization

The objectives of treating the Volar Barton fractures are

1. To restore the angular congruity
2. To achieve proper alignment
3. To regain the functional range of movements of wrist
4. To treat the associated injuries

Methods of management:

Various methods of managing the Volar Barton fractures are

a. Conservative management
b. Operative management
    1. Percutaneous pinning
    2. Spanning external fixation
    3. Non spanning external fixation
    4. Open reduction and dorsal plating
    5. Open reduction and volar plating
    6. Open reduction and internal fixation with locking compression plate
    7. Minimally invasive Percutaneous Plate Osteosynthesis
    8. Distraction plating

The overall goal of managing Volar Barton fractures is to obtain motion which is pain free and allowing the patient to return to their usual activities and to minimise the risk of development of early onset arthritis which may cause disability. Traditionally the distal radius fractures are treated conservatively by closed reduction and immobilisation with a splint or cast and this has been the treatment of choice for undisplaced and stable distal radius fractures.[6,99,100]

Due to the displacement nature of the Volar Barton fracture, in the general population, conservative management will fail. Therefore, surgical management is preferred.

A surgeon should consider the following signs as an alert that the fracture is unstable and indicate the closed reduction will not be sufficient.[101]

1. Dorsal comminution greater than 50% of the lateral radius width
2. Metaphyseal comminution over the palmar aspect
3. Initial dorsal tilt more than 20 degrees
4. Initial fragment displacement more than 1 cm
5. Radial shortening of more than 5 mm
6. Disruption of intra articular surface
7. Association of Ulna fracture
8. Severe osteoporosis

So, when electing patients to treat with conservative or operative therapy, it is better to include the patient in the management decision and allowing them to understand the pre management expectations. The choice of treatment should be always based on a two-way conversation with the patient.

Prognosis:

Intra articular fractures of distal radius including the Volar Barton fracture have a higher risk of development of post traumatic arthritis than the extra articular fractures. Articular step off of greater than 2mm increase the chance of post traumatic arthritis by 100%. [101] Elderly patients will have the worst prognosis and they are likely to have higher mortality due to the limitations of daily living.

For the achievement of good fracture healing, fracture gap should be minimal with adequate stability and sufficient nutrient supply. [102]

The distal radius is formed by massive cancellous bone. So, there would be plenty of blood supply and high bone forming potential but these fractures are more prone for malunion as Volar Barton fractures often produce volar subluxation of the carpus.[65] A malunion could be a serious disability and it may damage the articular cartilage as it has no blood supply.[103]

Complications:

The treating surgeon should be aware of the multiple injuries associated with the Volar Barton fractures like tears of TFCC, traumatic acute carpal tunnel syndrome, compartment syndrome of forearm at presentation and the development of Complex Regional Pain Syndrome (CRPS) during the follow up.[101]

Early complications of Volar Barton Fracture:

1. Difficult reduction
2. Depressed major articular components
3. Distal radio ulnar subluxation
4. Median or ulnar nerve compression
5. Acute carpal tunnel syndrome
6. Association of carpal injury [60]

Late complications:

1. Loss of reduction leading to secondary deformity
2. Malunion and intercarpal deformity due to collapse
3. Radiocarpal arthrosis

4. Distal radio ulnar dissociation
5. Carpal tunnel syndrome [60]

A. Conservative management:

Volar Barton fracture is an unusual injury. Satisfactory closed reduction is difficult to achieve. Even manipulation is successful, chance of recurrent dislocation may occur frequently. The redisplacement during healing is not correlated with the type of immobilization but only with the dorsal comminution and the initial displacement. Hence Volar Barton fracture needs proper anatomical reduction and rigid fixation as it is an unstable fracture. [104]

B. Operative management:

Pinning technique:

By forceful manipulation, the displaced volar fragment will be pushed back. After the reduction of the fragment and confirming with image intensifier, a Kirschner wire will be inserted from the radial styloid process to the ulnar side of the proximal cortex with a power hand-tool. The pin end will be bent and kept outside the skin. The fragment reduction was rechecked using the image intensifier. An external fixator will be applied to bridge the wrist joint and enforce wrist stability.[64]

ORIF with Plating:

Position of the patient: The patient is placed supine on the operating table. The forearm is rested on the hand table in the supinated position with the palm facing upward.

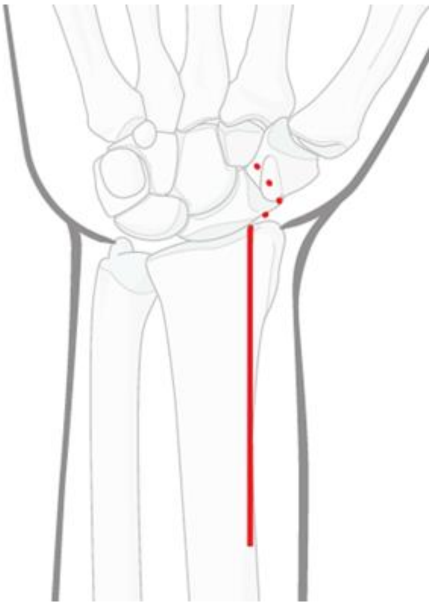
Landmarks and Incision:

The styloid process of the radius is palpated which is the most distal part of the radial aspect of the radius. Then towards the ulnar direction, flexor carpi radialis is palpated which is thick and mobile. Flexor carpi radialis lie radial to the palmaris longus muscle at the level of wrist and ulnar side to the radial artery.

Approach: Modified Henry's approach – This approach uses the plane between flexor carpi radialis and the radial artery. It is suitable for the fixation of most of the distal radius fractures. The modified Henry's approach is ulnar to the radial artery.

The incision is made along the radial border of the flexor carpi radialis tendon. The sheath is opened and the tendon is retracted towards the ulna.

Figure 30: Modified Henry's approach[105]



Adequate care must be taken to prevent damage to the radial artery on the radial side and palmar cutaneous nerve on the medial side. Flexor pollicis longus belly is swept towards the ulna by using finger. Thus, the space is increased and pronator quadratus muscle is exposed.

Then the pronator quadratus is incised using a L shaped incision. The horizontal limb is placed over the watershed line. It lies few milli meters proximal to the joint line. The pronator quadratus is incised on the radial border thus the distal radius is exposed. The muscle is striped off from the distal radius together with the periosteum.[106]

Figure 31: Pronator quadratus incision [107]

The fracture line is clearly visible now and it can be reduced by manipulation and ligamentotaxis. Provisional K wires are used to hold the reduction. The appropriate plate with 3.5 mm cortical and 4 mm cancellous screws are placed. The screw size is checked under C arm guidance to prevent the future complications. Pronator quadratus is sutured thus covering the distal end of the plate to prevent the tendon irritation. Thus, the plate functions in two ways – buttress the distal fragment and to maintain the reduction of metaphysis.[108]

IMPLANT FEATURES:

Based on the clinical demands and shift in biological and mechanical properties, the function and design of implants for the fixation of fractures have been evolved. The two-column variable angle locking compression plates combines the advantages of locked plating with Variable angle locking Holes which allow up to 15° off-axis screw angulation in all directions to address the individual fracture patterns providing fracture fragment specific fixation.[109]

Strictly subchondral screw placement avoiding intra-articular misplacement of the screw remains sometimes challenging, due to the fixed angle of the locking screw. It has been overcome by variable angle locking screws technique.

The plate system allows for the creation of construct that resists angular collapse. It also functions as an effective fracture reduction aid. The precise screws trajectories, anatomic contour and variable angle locking capabilities of variable locking compression plates provide a stable construct for predictable reconstruction of complex fractures of distal radius.

VA-LCP Two column volar distal radius plate provides various locking screw options in the head of the plate to optimally support the articular surface.

- Radial column fixed with radial screws
- Intermediate column fixed with ulnar screws

Figure 32: VA-LCP Two-Column Distal Radius Plate

It allows both buttressing and fixation of the two columns of the distal radius

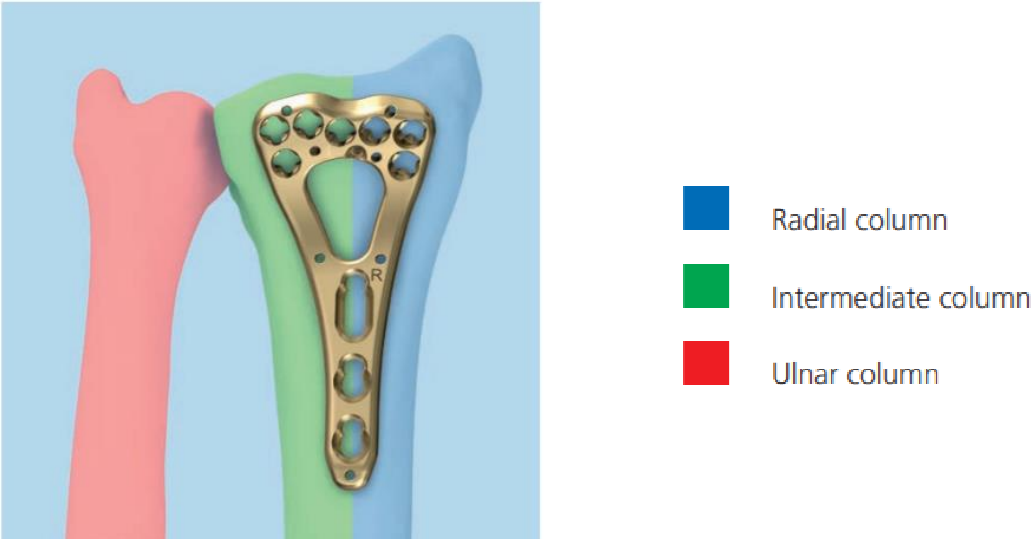


Plate:

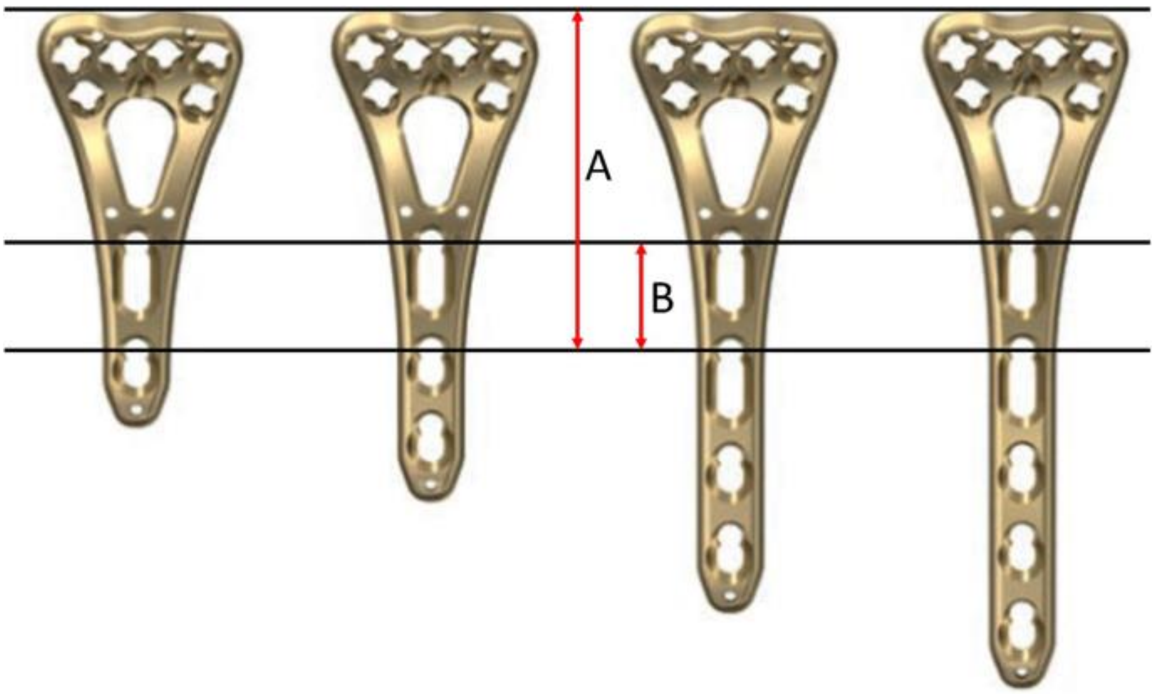
The VA-LCP distal radius plate is a 2.7 mm low profile stainless steel or titanium plate with a 26° distal volar tilt that allows for optimal anatomic fracture reduction and restoration of radial inclination.

The distal articular end of the plate consists of 4 locking holes for 2.7 mm locking screws angled at 15°.

The shaft of the plate has combi holes for insertion of 3.5mm locking or cortical screws.

The plates are available in 2, 3, 4, 5, 6, 7, 8 -hole shaft length.

Figure 33: Comparison of plates of different lengths. "The distance from the most distal end of the plate to the distal 2nd locking screw (A) is the same as the distance from the distal 1st to the distal 2nd screw (B), regardless of the length of the plate" [110]



SCREWS:

The screws are 2.7mm stainless steel or titanium self-tapping and locking screws.

Cup shaped Threaded head locks securely into the threaded holes in the plate to provide angular stability. The conical shape of the threaded head of fixed angle locking screws allows screw fixation only orthogonal to the plate hole, whereas the cup shaped threaded head of variable locking screws allows screw insertion in a variable angle up to 15° inclination. [110]

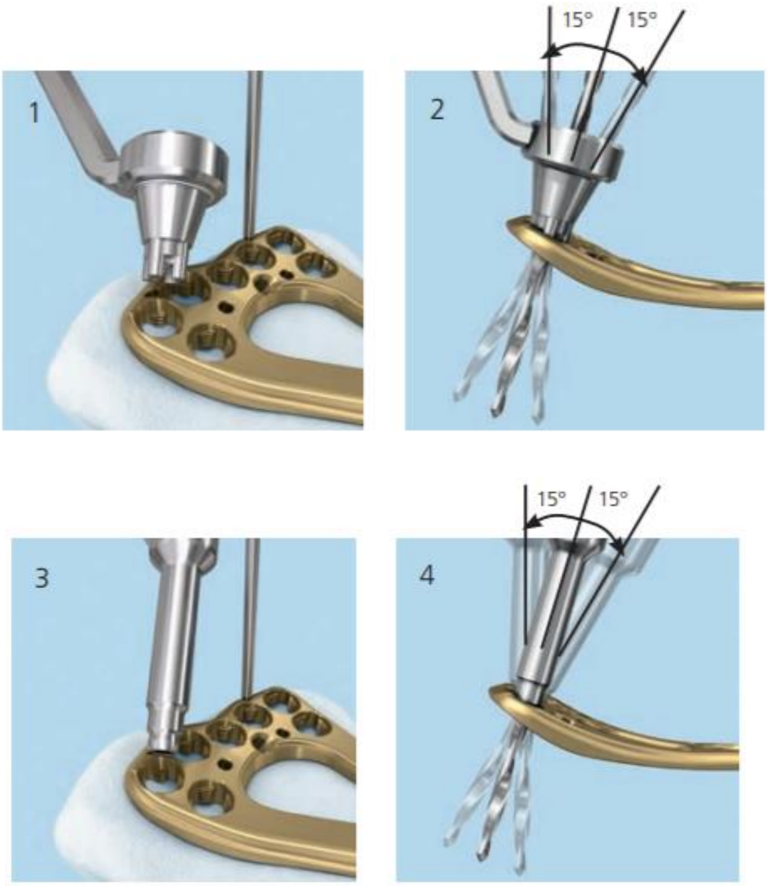
Locked screws allow unicortical screw fixation and load transfer to near cortex. It is available from 6mm to 30mm lengths (2mm increments).

To drill variable angle holes up to 15° deviation from the nominal trajectory of the locking hole, the tip of the VA-LCP drill sleeve and key inserted into the cloverleaf design of the Variable Angle locking hole.

Using funnel-shaped end of the VA-LCP drill sleeve variable angle holes are drilled at the desired angle.

Figure 34: Use of funnel shaped end of VA-LCP (1&2)

Use of Free hand VA-LCP sleeve (3&4)



DRILL BIT:

A 2mm regular drill bit is used for all the cancellous locking screws.

2.8mm regular drill bit for all the cortical locking and non-locking screws

COMPARISION BETWEEN LOCKING COMPRESSION PLATE AND VARIABLE LOCKING COMPRESSION PLATE:

The conventional fixed angle locking screws will provide stable Locking in the plate hole if inserted with in less than 5° of the precise perpendicular direction to the hole. Fixed angle locking screw applications are limited to the use of a drill sleeve correctly fixed in the threads of the plate hole. Without the use of the drill sleeve the correct screw insertion angle could not be maintained.

This led to the development of variable angle locking plate designs which enables to strategically place the locking screws at various desired angles. Strictly subchondral screw placement avoiding intraarticular misplacement of the screw remains challenging due to fixed angle of the locking screw.

The development of variable angle locking screws permitted an inclination of the screw insertion angle up to 15°. The variable angle locking screws have Cup shaped Threaded head which locks securely into the threaded holes in the plate to allow screw insertion into plate up to 15° inclination. Within this range of inclination, a locking strength comparable to fixed angle locking screws inserted in 0° inclination is provided.

The conical shape of the threaded head of fixed angle locking screws allows screw fixation only orthogonal to the plate hole, whereas the cup shaped threaded head of variable locking screws allows screw insertion in a variable angle up to 15° inclination.[111]

ADVANTAGES OF VA-LCP COMPARED TO LCP:

The variable locking mechanism maintains anchorage in inclined screw orientation, and intraarticular screw placement could be easier avoided. Very distally located radius fractures could be adequately addressed from a more proximal plate position respecting the watershed line.

VA-LCP has distal radial and ulnar “teardrop” holes that may be used to augment fixation of the radial styloid, lunate facet, and distal radial-ulnar joint.[111]

If the plate is positioned too proximal or angled to one side, subchondral support may be compromised, leading to dorsal migration of the distal fragment and prominent hardware, loosening, and/or tendinitis. Second, fixed angle plates are limited in how far distally they may be applied to avoid violation of the articular surface; occasionally, this may lead to insufficient volar coverage resulting in the catastrophic complication of volar carpal subluxation[112]

An exact subchondral screw placement reducing the subsidence in articular fractures is more efficient using variable angle locking screws.

In complex fracture patterns a fragment specific fixation requires screw orientation at a variable angle direction which can be performed by using a variable angle locking technique.

The primary indications for VA-LCPs:

1. Comminuted and intra articular fractures.

2. Poor quality bone as in osteoporosis

3. Complex periarticular fractures where contouring is difficult in the metaphyseal area

4. Inability to get minimal number of conventional cortical screw purchase

5. Periprosthetic fractures

6. Non-union due to screw stripping or back out

COMPLICATION AFTER VARIABLE ANGLE LOCKING COMPRESSION PLATING:

Irritation of the median nerve is very prevalent. Symptoms are usually minimal and go away when you get up. Carpal tunnel syndrome or median nerve neuropraxia over the fracture site may cause persistent paraesthesia.

1. Complications connected to the hardware, such as screw breakage, particularly at the head-neck junction.
2. A prominent plate causes skin discomfort at the wrist.
3. It's possible that alignment will be lost and malunion of fracture may occur. Small degrees of malunion are well tolerated by the elderly and cause minimal impairment. Reduced grip strength, aesthetic deformity, stiffness, restriction of forearm rotation, and pain can all be symptoms of severe malunion.
4. Complex regional pain syndrome
5. Infection
6. Failure of fixation, due to separation of the distal radius bony fragment from the plate may result.

ADVANTAGES OF VARIABLE ANGLE LOCKING COMPRESSION PLATING:

Volar column plates have the following attributes [112]:

1) It enables the surgeon to address individual fragments separately

2) Anatomical reduction depending on the pattern of fracture may be done and stabilization may be provided by using k-wires temporarily as the plate is applied.

3) Plates are provided with elongated holes that make it convenient to make adjustments in the position of the plates.

4) Universal anatomical shape eliminates need for anatomical contouring of plate based on variations in bone anatomy.

5) Stable Fixation: As the system is versatile, it allows stabilization of even complex fractures. In complex fractures treated based on the three-column theory, radius and ulnar fragments may be separately dealt with. Also, there are various locking options which is beneficial in fractures near distal radioulnar joint where additional screws may be used to support the styloid process.

6) Blood Supply preservation: The plates are specifically designed with a low-profile cross-sectional design with undercuts and rounded edges reducing chances of soft tissue irritation and ensuring good periosteal blood supply.

7) Early Mobilization: A combination of AO technique during surgery and the plate when used allow faster healing and early mobilization.

MATERIAL & METHODS

METHODOLOGY

40 patients who presented to the emergency medicine department of R.L. Jalappa Hospital or Outpatient department of Orthopaedics with history of self-fall, assault or road traffic accidents were considered for the study. Radiographs of the affected wrist was taken. The limb was immobilised with below elbow slab and fitness for surgery was taken. After informing about the risks and management plan, written informed consent was taken.

All patients were given injectable antibiotic (cephalosporins) half an hour prior to surgery and it was continued for 5 days post operatively. Advise to start making finger movements immediately in postop after the recovery of anaesthesia were given to all patients. The sutures were removed 2 weeks after surgery. Rehabilitation was started to achieve gains in active and passive wrist movements. The patients were regularly followed up at 1 month and 3 months and 6 months.

Check x- rays were taken for fracture union assessment and to assess fixation failure. Functional outcome after surgery was assessed by using DASH score and Gartland and Werley demerit criteria. Radiological outcomes after surgery will be assessed by using Sarmiento modification of Lindstrom criteria.

Inclusion criteria:

Patients aged between 18 to 60 years presenting with Closed Volar Barton fractures

Exclusion criteria:

Pathological fracture

Patients with delayed presentation (> 4 weeks)

STUDY DESIGN: Prospective, interventional, hospital-based study.

STUDY PERIOD:

40 patients having isolated Volar Barton fracture posted for variable locking plating are taken for the study at R.L. Jalappa Hospital& Research centre, Tamaka, Kolar from December 2019 to June 2021.

Sample size calculation:

Sample size for the study is estimated based on number of cases likely to get satisfying the inclusion and exclusion criteria during the period from December 2019 to June 2021. The study by Khatri K et al[122] had observed an excellent result in 65.2% of patients (p=65.2) considering an absolute error of 15% with 95% confident interval estimated Sample size is 40 cases of Volar Barton fracture. Chi square test will be used for testing significance. $p<0.05$ will be considered as statistically significant.

$$n = \frac{Z^2_{1-\alpha/2}\, p(1-p)}{d^2}$$

Where,

p : Expected proportion

d : Absolute precision

$1-\alpha/2$: Desired Confidence level

Immediate management:

Following admission, history from the patient was elicited to reveal the mode of injury and the severity of trauma. General condition of the patient and other systemic illness associated were noted. The findings were recorded in the patient proforma. Careful inspection of the swelling, deformity and evidence of ecchymosis were noted. Clinically tenderness, crepitus, abnormal mobility, distal sensation and distal pulsation were assessed. Movements of the wrist were checked.

Immobilization of the involved forearm with a below elbow POP slab was done and limb elevation was given. Pain and inflammation were treated using analgesics and anti-edema measures.

Preoperative planning:

Routine blood investigations such as Complete Blood Count, Renal Function Tests, Bleeding and Clotting time were sent. ECG and blood pressure were recorded in all the patients. Parts preparation was done for all the patients one day before surgery. Fitness for surgery and surgical consent was taken for all the patients. Tetanus toxoid injection, prophylactic antibiotic was given pre-operatively.

Surgical Procedure:

Anaesthesia: All the patients were operated under regional block or general anaesthesia

Position of the patient and Tourniquet application:

The patient was placed in supine position on the operating table. The affected arm was elevated for 2-3 minutes and exsanguinated using Esmarch tourniquet. Then the mid arm pneumatic tourniquet was applied.

The affected limb was positioned on the side arm board by abducting the shoulder. The placement of the limb should be in the way that allows complete imaging in the sagittal and coronal plane of the distal radius.

Forearm and hand were properly scrubbed, painted with betadine solution and spirit and then draped.

Instruments and Implants used:

- Variable angle Locking compression plates of varying length.
- 2.7mm LCP drill bit and sleeve system.
- Hand drill / power drill.
- Tap for 3.5mm cortical screws and 3.5mm depth gauge.
- Hexagonal screw driver for 2.7mm &3.5mm locking screws and 3.5mm cortical screws.
- General instruments like retractors, periosteal elevators, reduction clamps, bone levers etc
- Pneumatic tourniquet.

Operative procedure:

Modified Henry's approach: – The plane between flexor carpi radialis and the radial artery is used in this approach. It is suitable for the fixation of most of the distal radius fractures. The modified Henry's approach is ulnar to the radial artery.

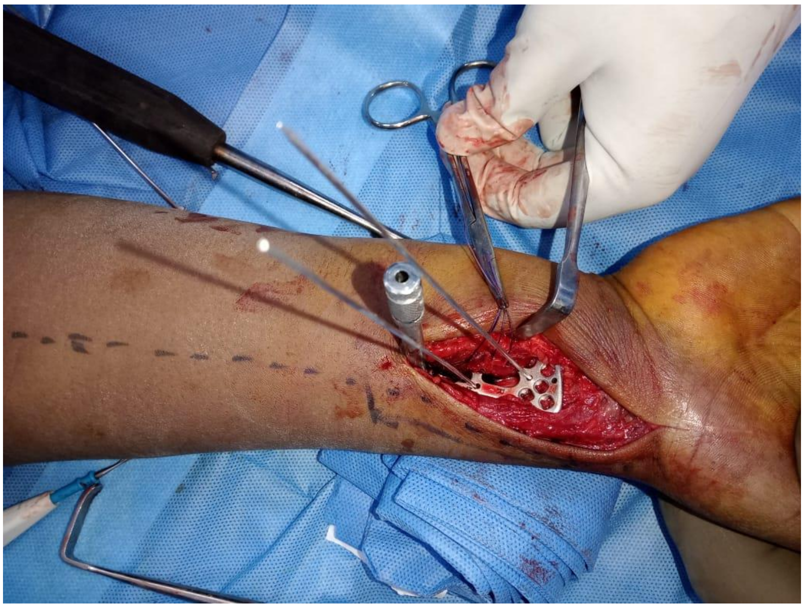
The incision is made along the radial border of the flexor carpi radialis tendon. The sheath is opened and the tendon is retracted towards the ulna.

Adequate care was taken to prevent damage to the radial artery on the radial side and palmar cutaneous nerve on the medial side. Flexor pollicis longus belly is swept towards the ulna by using finger. Thus, the space is increased and pronator quadratus muscle is exposed.

Then the pronator quadratus muscle is incised using a L shaped incision. The horizontal limb is placed over the watershed line. It lies few milli meters proximal to the joint line. The pronator quadratus is incised on the radial border thus the distal radius is exposed. The muscle is striped off from the distal radius together with the periosteum.

The fracture line would be clearly visible now and reduced by manipulation and ligamentotaxis. Provisional K wires are used to hold the reduction.



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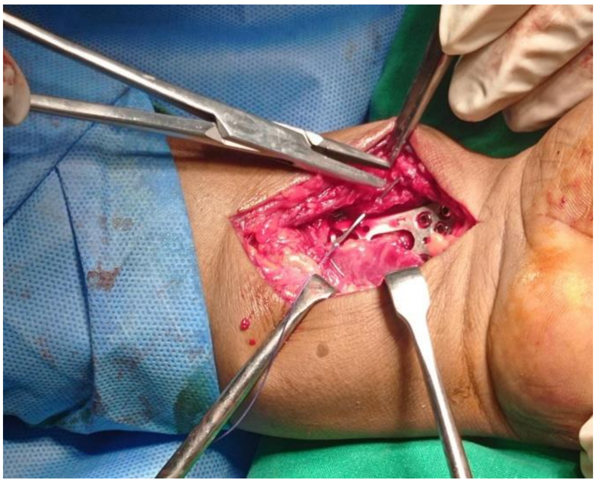
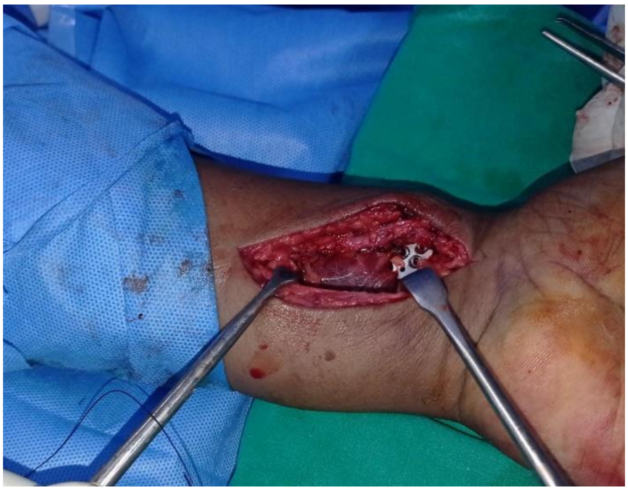
Pronator quadratus is sutured thus covering the distal end of the plate to prevent the tendon irritation. Thus, the plate functions in two ways – buttress the distal fragment and to maintain the reduction of metaphysis.





Postoperative protocol:

Postoperatively the patients were advised to move the wrist after 2 weeks, postoperative complications such as symptoms of median nerve compression, non-union, malunion, failure of fixation, wound infection and Complex regional Pain syndrome were assessed and documented.

After discharge, patients were regularly followed up at 1 month, 3 month and 6-month intervals regularly. Range of motion was measured at every follow-up. The assessment of Functional outcomes was made using DASH Score and Gartland and Werley Demerit criteria. Radiological outcomes were assessed using Sarmiento modification of Lindstrom Criteria.

Gartland and Werley Scoring System

Residual deformity (Range, 0 to 3 points)

Prominent ulnar styloid:	1
Residual dorsal tilt:	2
Radial deviation of hand:	3

Subjective evaluation (Range 0 to 6 points)

Excellent: No pain, Disability or limitation of motion	0
Good: Occasional pain, slight limitation of pain and no disability	2
Fair: Occasional pain, some limitation of motion, Feeling of weakness in wrist, no particular disability and slight activity restriction	4
Poor: Pain, Limitation of motion, Disability and activities more or less markedly restricted.	6

Objective evaluation (Range 0 to 5 points)

Loss of extension	5
Loss of ulnar deviation	3
Loss of supination	2
Loss of flexion	1
Loss of radial deviation	1

Loss of circumduction	1
Pain in distal radio ulnar joint	1
Grip strength: 60% or less than the opposite side	1
Loss of pronation	2

Complications (Range 0-5 points)

Arthritic change

Minimum	1
Minimum with Pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complications	1-3
Poor function due to cast	1-2

Final results: (Range of Points)

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

Gartland and Werley Scoring [113] is the method to analyze the outcome which is point based and used to evaluate the wrist function. This scale was developed initially in 1951 and used for the evaluation of Colle's fracture. The original scoring is based on a "demerit" system involving the subjective and objective aspects related to hand and wrist function, residual deformities, range of motion and complications.

Method of use:

The scoring is based on the list of items such as

1. Residual deformity
2. Subjective evaluation
3. Objective evaluation
4. Complications

Each assessment is based on the demerit point system. The total score of the four domains is then added up to get the final score of the assessment.

DASH SCORE

The Disability of Arm, Shoulder and Hand questionnaire[114] is a specific outcome measure for the upper extremity which was introduced by AAOS in collaboration with number of organizations. One of the main concepts behind the development of DASH scoring is to facilitate comparison among the different conditions of upper extremity in terms of heath burden.

DASH scoring is being increasingly used in Cross sectional studies. The DASH's key element is a 30-item disability/symptom scale that evaluates the patient's health state during the prior visit. The items inquire about the degree of difficulty in performing various physical activities as a result of the arm, shoulder, or hand problem (21 items), the severity of each of the pain symptoms, activity-related pain, tingling, weakness, and stiffness (5 items), and the impact of the problem on social activities, work, sleep, and self-image (4 items). There are five response possibilities for each item. The scores for all elements are then added together to get a scale score ranging from 0 (no disability) to 100 (complete disability)

Disabilities of the Arm, Shoulder and Hand

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. Open a tight or new jar.	1	2	3	4	5
2. Write.	1	2	3	4	5
3. Turn a key.	1	2	3	4	5
4. Prepare a meal.	1	2	3	4	5
5. Push open a heavy door.	1	2	3	4	5
6. Place an object on a shelf above your head.	1	2	3	4	5
7. Do heavy household chores (e.g., wash walls, wash floors).	1	2	3	4	5
8. Garden or do yard work.	1	2	3	4	5
9. Make a bed.	1	2	3	4	5
10. Carry a shopping bag or briefcase.	1	2	3	4	5
11. Carry a heavy object (over 10 lbs).	1	2	3	4	5
12. Change a lightbulb overhead.	1	2	3	4	5
13. Wash or blow dry your hair.	1	2	3	4	5
14. Wash your back.	1	2	3	4	5
15. Put on a pullover sweater.	1	2	3	4	5
16. Use a knife to cut food.	1	2	3	4	5
17. Recreational activities which require little effort (e.g., cardplaying, knitting, etc.).	1	2	3	4	5
18. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	1	2	3	4	5
19. Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.).	1	2	3	4	5
20. Manage transportation needs (getting from one place to another).	1	2	3	4	5
21. Sexual activities.	1	2	3	4	5

DISABILITIES OF THE ARM, SHOULDER AND HAND

	NOT AT ALL	SLIGHTLY	MODERATELY	QUITE A BIT	EXTREMELY
22. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups? *(circle number)*	1	2	3	4	5

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
23. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem? *(circle number)*	1	2	3	4	5

Please rate the severity of the following symptoms in the last week. *(circle number)*

	NONE	MILD	MODERATE	SEVERE	EXTREME
24. Arm, shoulder or hand pain.	1	2	3	4	5
25. Arm, shoulder or hand pain when you performed any specific activity.	1	2	3	4	5
26. Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4	5
27. Weakness in your arm, shoulder or hand.	1	2	3	4	5
28. Stiffness in your arm, shoulder or hand.	1	2	3	4	5

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
29. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? *(circle number)*	1	2	3	4	5

	STRONGLY DISAGREE	DISAGREE	NEITHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
30. I feel less capable, less confident or less useful because of my arm, shoulder or hand problem. *(circle number)*	1	2	3	4	5

DASH DISABILITY/SYMPTOM SCORE = _____ ([(sum of n responses / n) - 1] x 25, where n is the number of completed responses.)

A DASH score may <u>not</u> be calculated if there are greater than 3 missing items.

SARMIENTO MODIFICATION OF LINDSTROM CRITERIA

Lindstrom criteria for anatomical end results of distal radius fractures:

GRADE 1:

- No significant deformity.
- Dorsal angulation not exceeding neutral position.
- Radial shortening <3 mm.

GRADE 2:

- Slight deformity.
- Dorsal angulation 1 to 10 degrees.
- Radial shortening 3 to 6 mm.

GRADE 3:

- Moderate deformity.
- Dorsal angulation 11 to 14 degrees.
- Radial shortening 7 to 11 mm.

GRADE 4:

- Severe deformity.
- Dorsal angulation >15 degrees.
- Radial shortening > 12 mm

Table 10: Sarmiento's modification of Lindstrom criteria for the radiological evaluation of distal radius fractures:

	Residual deformity	**Loss of palmar tilt (°)**	**Radial shortening (mm)**	**Loss of radial deviation (°)**
Excellent	Insignificant	0	< 3	5
Good	Slight	1-10	3-6	5-9
Fair	Moderate	11-15	7-11	10-14
Poor	Severe	At least 15	At least 12	> 14

RESULTS

RESULTS:

A total of 40 subjects were included in the final analysis

Table 11: Descriptive analysis of age (in years) in study population (N=40)

Parameter	Mean ± SD	Median	Minimum	Maximum	95% C. I	
					Lower	Upper
Age (in years)	36.43 ± 10.59	35.50	20.00	58.00	33.04	39.81

The mean age was 36.43 ± 10.59 years, ranged from 20 to 58 years. (Table 11)

Table 12: Descriptive analysis of gender in the study population (N=40)

Gender	Frequency	Percentages
Male	30	75.00%
Female	10	25.00%

Among the study population 30(75%) were male and remaining 10(25%) were female, (Table 12& Figure 35)

Figure 35: Pie chart of gender in the study population (N=40)

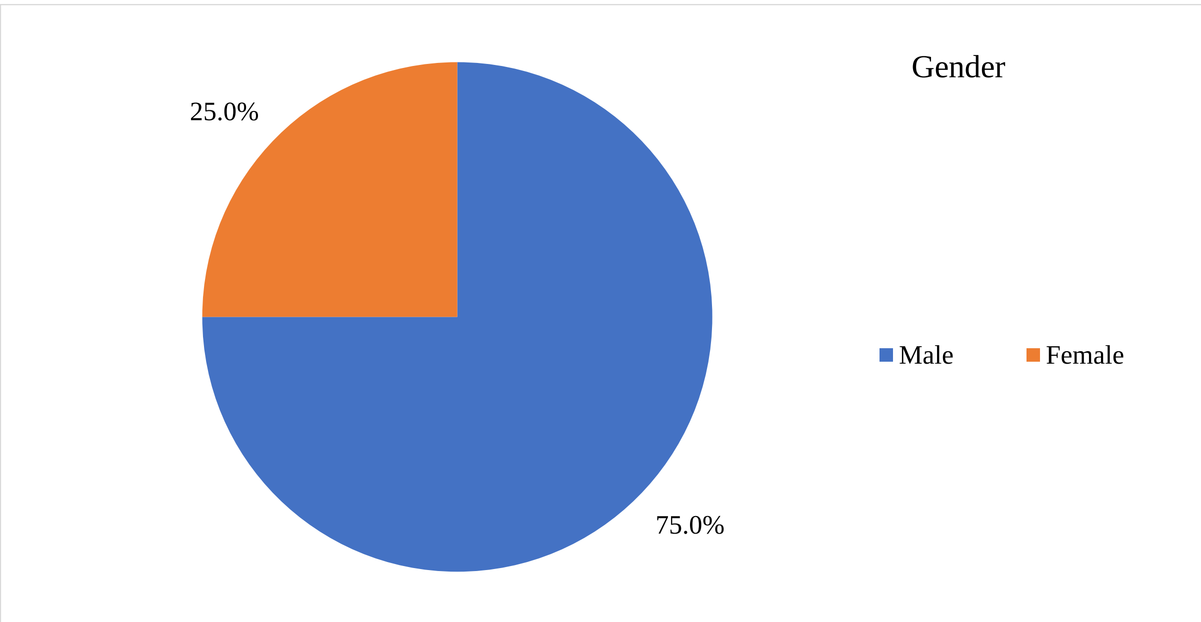


Table 13: Descriptive analysis of mode of injury in the study population (N=40)

Mode of injury	Frequency	Percentages
Fall from height	9	22.50%
RTA	31	77.50%

Among mode of injury, 9(22.50%) had fall from height and 31(77.50%) had RTA. (Table 13& Figure 36)

Figure 36: Pie chart of mode of injury in the study population (N=40)

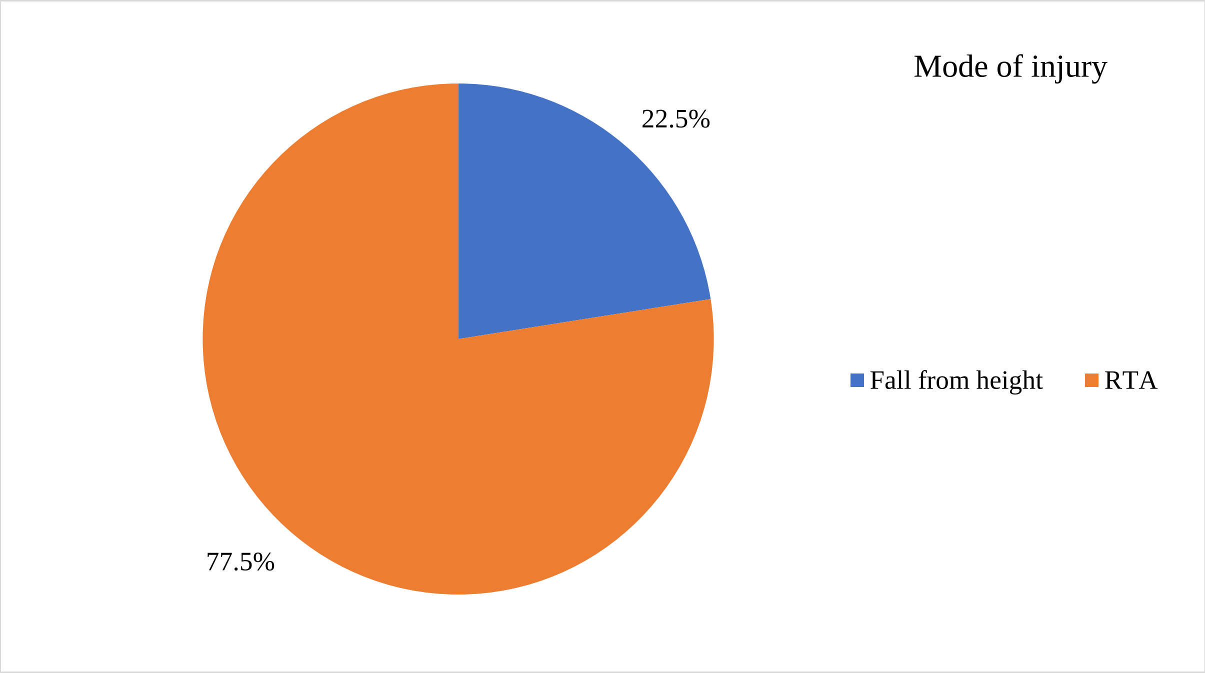


Table 14: Descriptive analysis of side in the study population (N=40)

Side	Frequency	Percentages
Right	24	60.00%
Left	16	40.00%

Among the study population, 24(60%) ha right side and 16(40%) had left side. (Table 14& Figure 37)

Figure 37: Pie chart of side in the study population (N=40)

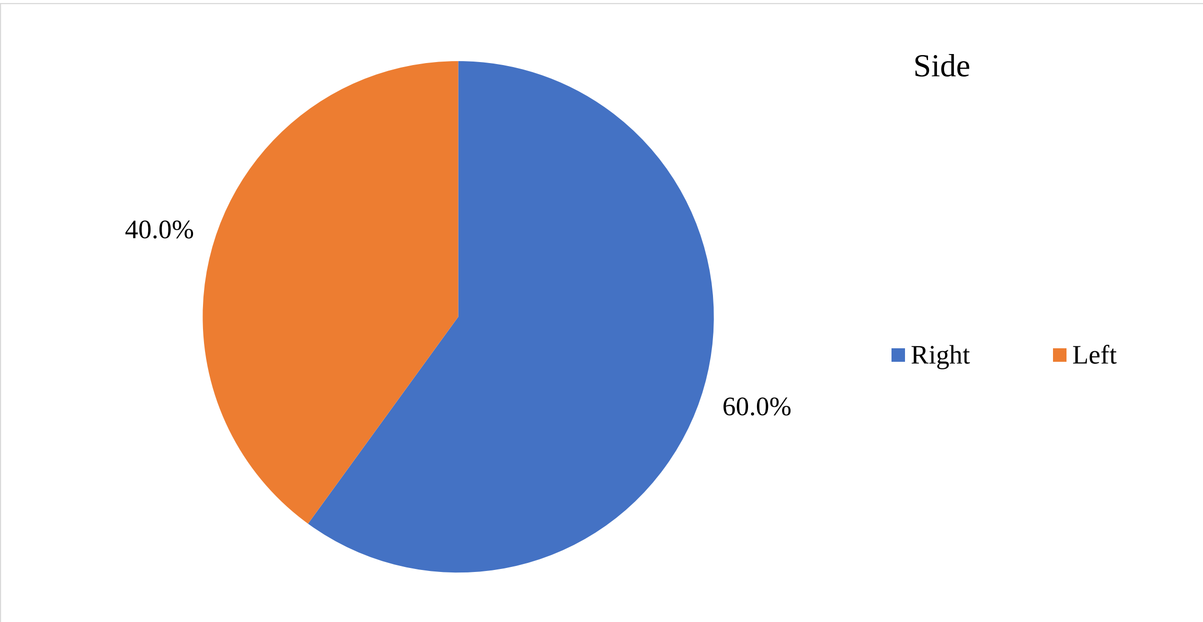


Table 15: Descriptive analysis of range of motion in study population (N=40)

Parameter	Mean ± SD	Minimum	Maximum
Flexion	70.63° ± 3.6°	65.0°	78.0°
Extension	74.3° ± 3.64°	68.0°	80.0°
Radial Deviation	10.15° ± 1.55°	6.0°	12.0°
Ulnar Deviation	30.58° ± 3.2°	25.0°	38.0°
Supination	79.83° ± 2.67°	75.0°	85.0°
Pronation	76.28° ± 1.99°	72.0°	80.0°

The mean flexion was 70.63° ± 3.6°, ranged from 65° to 78°), the mean extension was 74.3° ± 3.64° ranged from 68° to 80°, the mean radial deviation was 10.15° ± 1.55°, ranged from 6° to 12°, the mean ulnar deviation was 30.58° ± 3.2°, ranged from 25° to 38°, the mean supination was 79.83° ± 2.67°, ranged from 75° to 85° and the mean pronation was 76.28° ± 1.99° ranged from 72° to 80° in the study population. (Table 15)

Table 16: Descriptive analysis of functional outcome in study population (N=40)

Parameter	Mean ± SD	Minimum	Maximum
DASH Score	13.98 ± 5.76	5.0	30.0
Gartland and Werley demerit criteria score	2.73 ± 2.37	0.00	10.00

The mean DASH score was 13.98 ± 5.76, ranged from 5 to 30 and the mean Gartland and Werley demerit criteria score was 2.73 ± 2.37, ranged from 0 to 10. (Table 16)

Table 17: Descriptive analysis of G.W. outcome in the study population (N=40)

G.W. Outcome	Frequency	Percentages
Excellent	26	65.00%
Good	12	30.00%
Fair	2	5.00%

Among the study population, 26(65%) had excellent outcome, 12(30%) had good outcome and 2(5%) had fair outcome. (Table 17& Figure 38)

Figure 38: Bar chart of G.W. outcome in the study population (N=40)

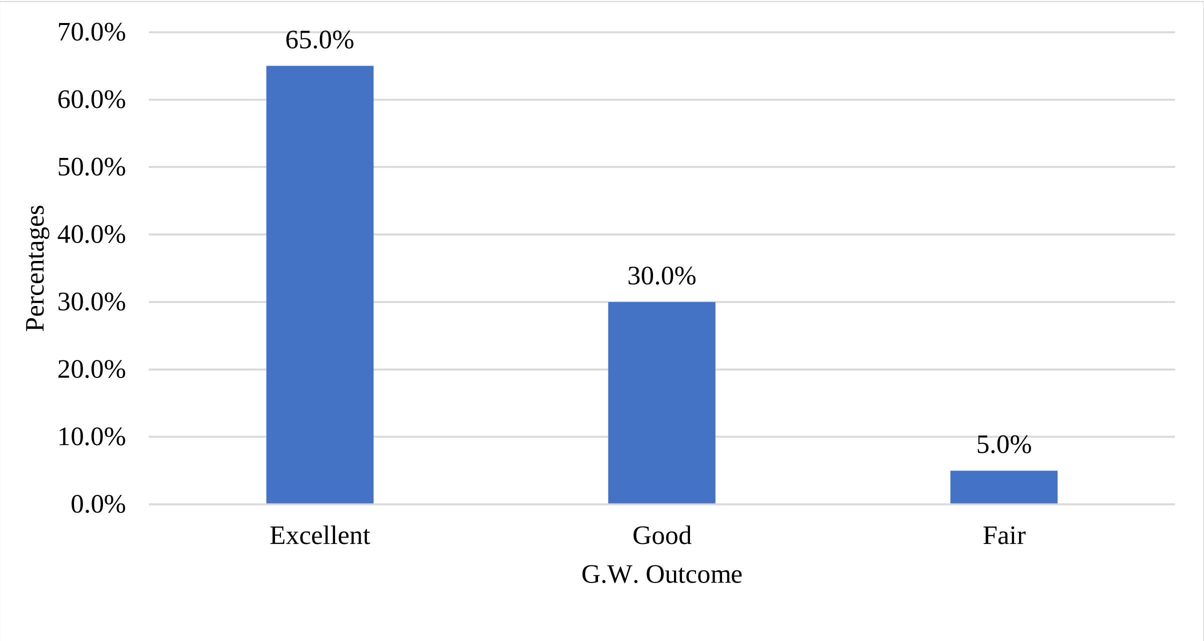


Table 18: Descriptive analysis of residual deformity in the study population (N=40)

Residual Deformity	Frequency	Percentages
Insignificant	30	75.00%
Slight	10	25.00%

Among the residual deformity, 30(75%) had insignificant and 10(25%) had slight. (Table 18 & Figure 5)

Figure 39: Pie chart of residual deformity in the study population (N=40)

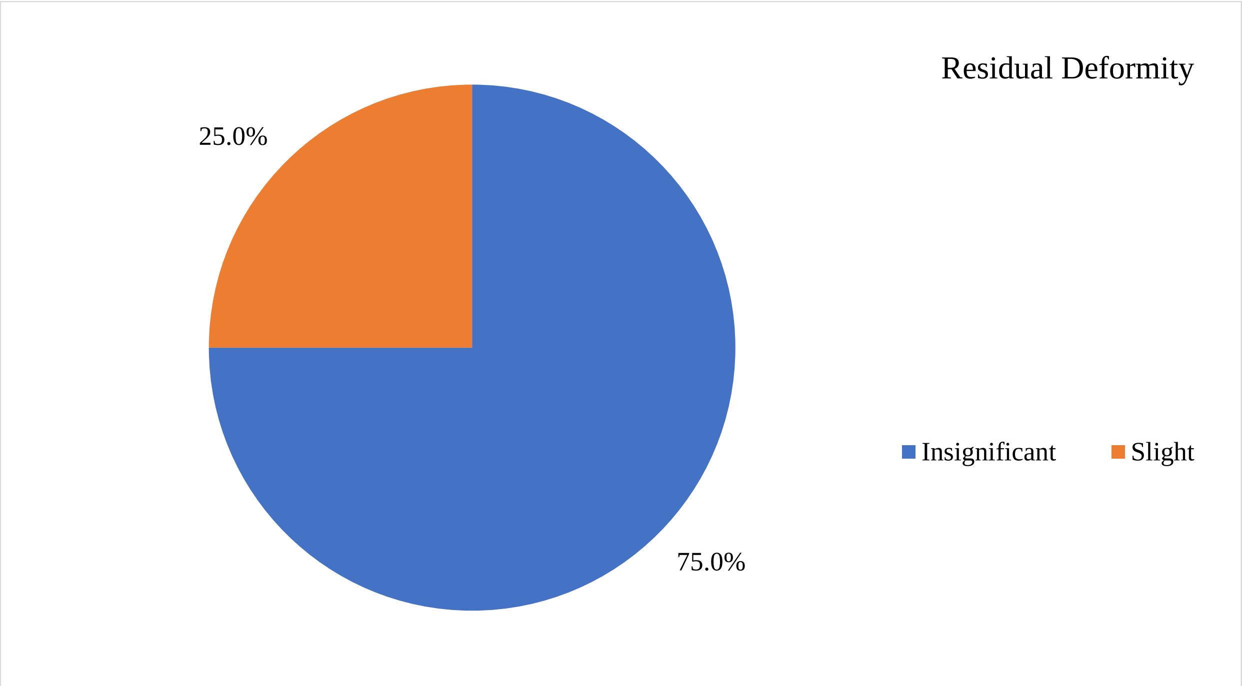


Table 19: Descriptive analysis of objective evaluation in study population (N=40)

Parameter	Mean ± SD	Minimum	Maximum
Loss of palmar tilt	4.6° ± 3.75°	0.00	12.00
Radial shortening (mm)	4 ± 1.75	1.00	7.00
Loss of radial inclination	6.15° ± 2.83°	0.00	12.00

The mean loss of palmar tilt was 4.6° ± 3.75°, ranged from 0° to 12°, the mean radial shortening was 4mm ± 1.75mm ranged from 1mm to 7mm and the mean loss of radial inclination was 6.15° ± 2.83°, ranged from 0° to12°. (Table 19)

Table 20: Descriptive analysis of radiological outcome the study population (N=40)

Radiological outcome	Frequency	Percentages
Good	22	55.00%
Excellent	11	27.50%
Fair	7	17.50%

Among the study population, 22(55%) had good radiological outcome, 11(27.50%) had excellent outcome and 7(17.50%) had fair outcome. (Table 20 & Figure 40)

Figure 40: Bar chart of radiological outcome in the study population (N=40)

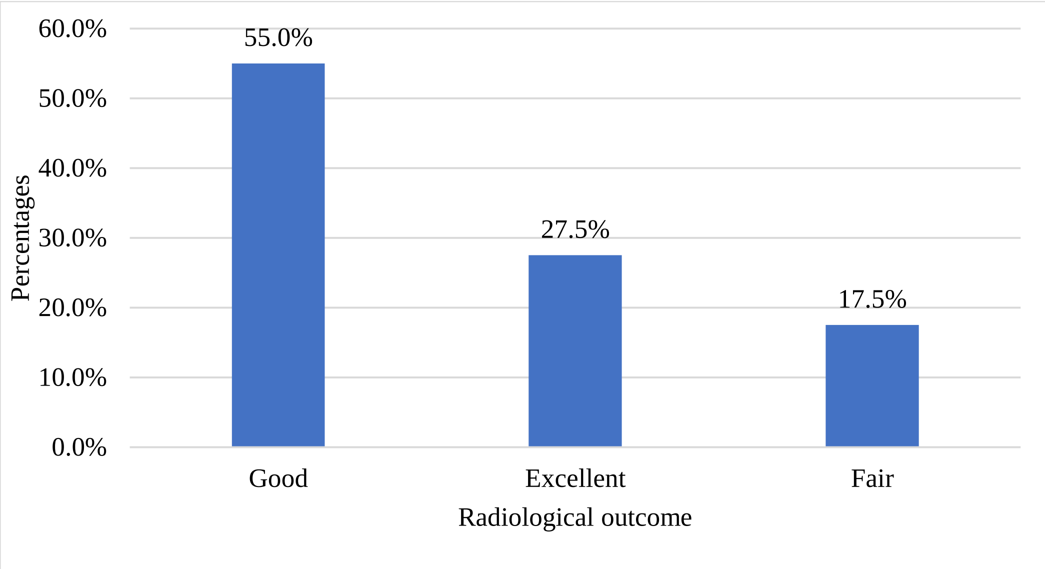


Table 21: Descriptive analysis of complications in the study population (N=40)

Complications	Frequency	Percentages
Hypertrophic scar	2	5.00%
Superficial infection	2	5.00%
Complex regional pain syndrome	1	2.50%
NIL	35	87.50%

Among the study population, 2(5%) had hypertrophic scar and superficial infection for each and 1(2.50%) had complex regional pain syndrome. (Table 21)

Table 22: Comparison of mean dash score across the study groups (N=40)

Radiological outcome	DASH Score Mean ± SD	Mean difference	95% CI		P value
			Lower	Upper	
Good	12.94 ± 5.32				
Excellent	13.09 ± 5.41	0.15	-3.94	4.25	0.939
Fair	18.66 ± 6.05	5.72	0.91	10.53	0.021

The Mean DASH score keeping radiological outcome as good was 12.94 ± 5.32, it was 13.09 ± 5.41 excellent and it was 18.66 ± 6.05 in fair. Taking radiological outcome good as base line, the mean difference of DASH score (0.15) in excellent was statistically not significant (P value 0.939) and in fair (5.72) was statistically significant (P value 0.021). (Table 22& Figure 7)

Figure 41: Error bar chart of comparison of DASH score across the study groups (N=40)

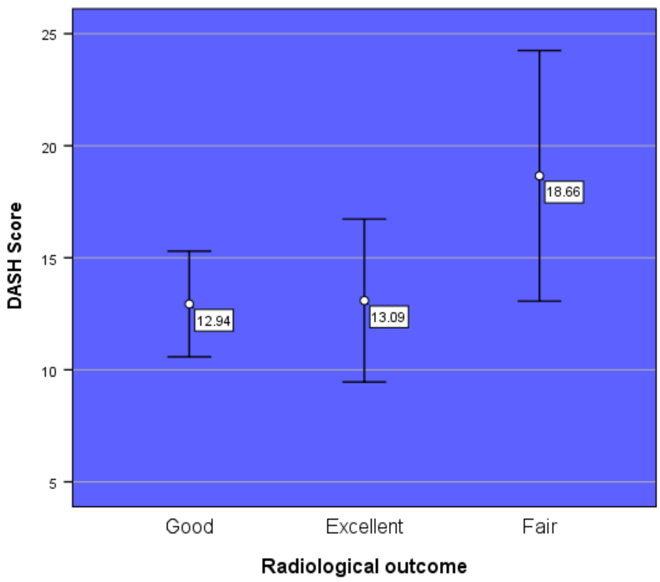
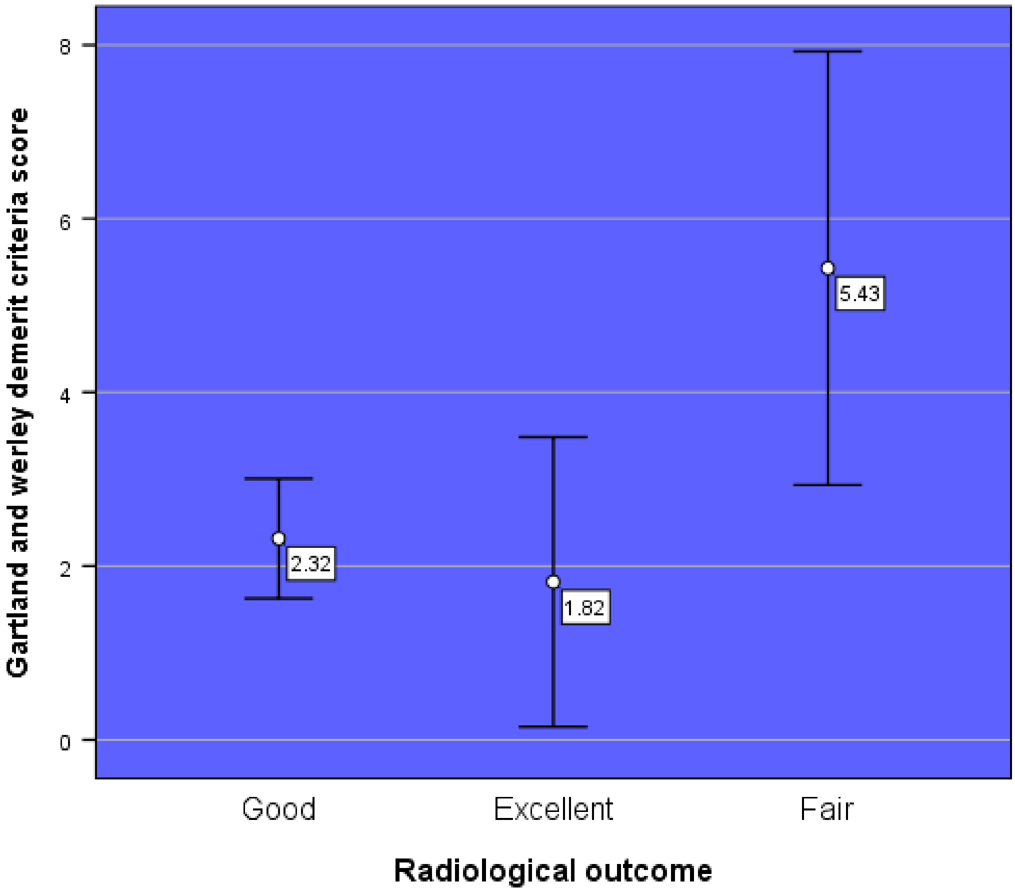


Table 23: Comparison of mean Gartland and Werley demerit criteria score across the study groups (N=40)

Radiological outcome	Gartland and Werley demerit criteria score Mean ± SD	Mean difference	95% CI		P value
			Lower	Upper	
Good	2.32 ± 1.55				
Excellent	1.82 ± 2.48	0.50	-1.04	2.04	0.514
Fair	5.43 ± 2.7	3.11	1.30	4.92	0.001

The Mean Gartland and Werley demerit criteria score with in radiological good outcome was 2.32 ± 1.55, it was 1.82 ± 2.48 excellent and it was 5.43 ± 2.7 in fair. Taking radiologically good outcome as base line, the mean difference of Gartland and Werley demerit criteria score (0.50) in excellent was statistically not significant (P value 0.514) and in fair (3.11) was statistically significant (P value 0.001). (Table 23 & Figure 42)

Figure 42: Error bar chart of comparison of Gartland and Werley demerit criteria score across the study groups (N=40)



DISCUSSION

DISCUSSION:

Open reduction and internal fixation restore the wrist's anatomy and help in faster rehabilitation with good clinical outcomes in cases of Volar Barton Fractures.[115] Volar plating is currently favoured for comminuted distal end radius fracture patterns and osteoporotic bones.[116] The volar cortex of the distal end radius is often less comminuted than the dorsal cortex; therefore, anatomical reduction of the palmar cortex restores the radial shortening. Moreover, the palmar cortex is better contoured with respect to the dorsal cortex in terms of plate application. There had been a shift in focus from the use of non-locking volar plates to locking volar plates as the latter provides secure and reliable fixation of complex fractures due to angular stability.[117,118] Kanabar et al,[117] reported that early mobilization in fractures treated with volar fixed locking plates does not lead to a decrease in the radiological parameters achieved at the final follow-up. The present study aimed to assess Functional outcomes in Volar Barton fractures treated with Variable locking plates by using DASH score and Gartland and Werley demerit criteria and to assess the Radiological outcomes using Sarmiento modification of Lindstrom criteria.

The present study involved 40 subjects with mean age of 36.43 ± 10.59 years, ranged from 20 to 58 years. Majority of the study subjects were males (75%) and females were 25%. RTA was the major cause of injury in 77.50% and fall from height in 22.50%. Nearly 60% had right side injury and 40% had left side injury. A study by Kundu, A et al,[119] found that 30 patients treated with volar locking plate system where 46.6% were male subjects and 53.33% were female and average age was 42 years and range were 18-64 years and had right side injury in majority. Another study by Kolla, R et al,[120] included 20 cases with volar Barton's fractures with majority of subjects in the 31-40 years of age group (45%) followed by 41-50 and 20-30 years in 25% each respectively. Males (80%) were affected most than females

(20%) and left side (65%) was most injured than right side (35%). Road traffic accidents (60%) was the most common cause for injury and 40% were due to Fall on An Outstretched Hand (FOOH).

Table 24: Table comparing the patient demographics across various studies with present study

Studies	**Gender**	**Age**
Kundu, A et al,[119]	46.6% male 53.33% female	18-64years
Kolla, R et al,[120]	80% males 20%females	20-60 years
Present study	75% males 25% female	20-58years

Table 25: Table comparing the mode of injury across different studies to present study

Studies	RTA	FOOH
Kolla, R et al,[120]	60%	40%
Chung, K et al,[121]	42	45
Present study	77.50%	22.50%

The present study observed, the mean flexion was 70.63° ± 3.6°, the mean extension was 74.3° ± 3.64°, the mean radial deviation was 10.15° ± 1.55°, the mean ulnar deviation was 30.58° ± 3.2°, the mean supination was 79.83° ± 2.67° and the mean pronation was 76.28° ± 1.99°. A study by Khatri, K et al,[122] at final follow up found the mean flexion to be 71.91° ± 8.08°, extension was 76.95° ± 5.70°, pronation was 77.65° ± 6.01°, supination was 81.86° ± 6.28°. The present study results were in comparison to Khatri, K et al,[122] study.

Table 26: Table comparing the clinical outcome measures across different studies to present study

	Khatri, K et al,[112]	**Present study**
Flexion	71.91° ± 8.08°	70.63° ± 3.6°
Extension	76.95° ± 5.70°	74.3° ± 3.64°
pronation	77.65° ± 6.01°	76.28° ± 1.99°
supination	81.86° ± 6.28°	79.83° ± 2.67°

The mean loss of palmar tilt was 4.6° ± 3.75°, ranged from 0° to 12°, the mean radial shortening was 4mm ± 1.75mm ranged from 1mm to 7mm and the mean loss of radial inclination was 6.15mm ± 2.83mm, ranged from 0mm to12mm. A retrospective study by Khatri, K et al,[122] found the average radial inclination loss to be 0.68 mm, radial length was 0.1 mm, volar angle was 0.26°, and ulnar variance was 0.16 mm, and found that the change in indices was statistically insignificant. Further this study observed clinical parameters (flexion, extension, supination, and pronation) measured at eight weeks and at final follow-up revealed significant improvement. However, in our study although we followed the patients at 3 and 6 months, we did not compare the mean scores at these intervals. In another study by Kundu, A et al, [5]At final follow-up, the average volar tilt was 6.7° (range, 2° of dorsal tilt to 15° of volar tilt), radial inclination averaged 20.2° (range, 12–28°) and radial shortening averaged 0.7 mm (range, 0–2 mm). They found loss of volar tilt and trauma surgery interval correlating inversely to the functional outcome significantly (p value<0.05).

In the present study, the mean DASH score was 13.98 ± 5.76, the mean Gartland and Werley demerit criteria score was 2.73 ± 2.37. Jagodzinski et al.[123] reported a mean DASH score of 18.2 in patients treated with VA-LCP.

Based on Gartland and Werley outcome, majority (65%) of the study population to have excellent outcome, 30% had good outcome and only 5% had fair outcome. A similar result was found by Kolla R et al,[120] with Gartland and Werley outcome found excellent outcome in 55%, good in 35%, fair in 5% and poor in 5% of their study population. Another study by Kundu, A et al,[119] with similar results of the present study found excellent outcome in 70%, good in 16%, fair in 14%.

Table 27: Table comparing the GW outcome percentage across the study population in various studies to present study

	Kolla, R et al [120]	**Kundu, A et al [119]**	**Present study**
Excellent	55%	70%	65%
Good	35%	16%	30%
Fair	5%	14%	5%
Poor	5%	-	

Based on the anatomical and radiological evaluation using Sarmiento modification of Lindstrom criteria ,we found the residual deformity, 30(75%) had insignificant and 10(25%) had slight. A study by Kundu, A et al,[5] found residual deformity, to be excellent in 80%, good in 40%, poor in 7%.

Among the study population, 22(55%) had good radiological outcome, 11(27.50%) had excellent outcome and 7(17.50%) had fair outcome.

The present study showed, hypertrophic scar and superficial infection in 5% each and 2.50% had complex regional pain syndrome. In Kolla R et al,[120] found arthritis of wrist joint in 15%, malunion fracture in 10%, Extensor pollicis longus tendon irritation in 5% due to long screw placement through the outer cortex irritate the tendon and one patient showed complex regional pain syndrome. The overall complications reported in Kundu, A et al,[119] was 18%. And found There were two cases of superficial wound infection that settled well with oral antibiotics. No patients had complex regional pain syndrome or non-union and none had extensor tendon irritation or ruptures. Residual pain, stiffness and deformity were there are about 10% of the subjects.

In the present study, the mean DASH score with in radiological outcome good was 12.94 ± 5.32, it was 13.09 ± 5.41 excellent and it was 18.66 ± 6.05 in fair. Taking radiological outcome good as base line, the mean difference of DASH score (0.15) in excellent was statistically not significant (P value 0.939) and in fair (5.72) was statistically significant (P value 0.021). The Mean Gartland and Werley demerit criteria score with in radiological good outcome was 2.32 ± 1.55, it was 1.82 ± 2.48 excellent and it was 5.43 ± 2.7 in fair. Taking radiologically good outcome as base line, the mean difference of Gartland and Werley demerit criteria score (0.50) in excellent was statistically not significant (P value 0.514) and in fair (3.11) was statistically significant (P value 0.001). A retrospective study by Khatri, K et al,[122] observed Gartland and Werley's demerit scoring system showed 65.22% subjects had excellent results, while 34.78% had good results. In a similar study by Figl et al,[124] reported excellent results in 37.5% of subjects, good results in 67%, and fair results in 1%. The results are, however, not truly comparable with those of the current study as a different scoring system was used in the evaluation of the results.

CONCLUSION

CONCLUSION:

The present study was held to assess the functional and radiological outcomes of Volar Barton fracture fixed with variable locking plate and the following points were concluded. Majority of them were male patients due to their outdoor activities and road traffic accidents. Most of the fractures occur in younger individuals due to high velocity injuries.

As per many studies, variable locking plates provide successful results for the treatment of distal radius fractures with intra articular extension and unstable in nature. Variable locking plates used for the management of Volar Barton fractures provides efficient anatomic reduction, thus helping in early joint motion because of its rigid fixation. Modified Henry's approach provides better accessibility with less surgical trauma while fixing Volar Barton fractures with an adaption in a better way to the surrounding tissues. Most of the patients who were young adults, returned to their daily activity comfortably.

We faced some complications during the study like hypertrophic scar, superficial infection and complex regional pain syndrome. But these complications resolved and do not hinder the day-to-day activities of the patients in their final follow up.

Use of variable locking plates in Volar Barton fractures provide good to excellent functional outcomes and excellent radiological outcome in majority of the patients. But the restoration of normal radiological parameters might not be necessary for the achievement of a better functional outcome.

LIMITATIONS AND RECOMMENDATIONS:

- The study was a single centre study with limited sample size limiting our results.
- Comparison with other modes of fixation was not done.
- Inclusion of control group could have given a better comparison
- Large multicentric studies with cases and control group can further help in managing distal radius plating to prevent any complications and adverse outcomes.

SUMMARY

SUMMARY:

The study was a prospective study design which aimed to assess Functional outcomes in Volar Barton fractures treated with variable locking plates by using DASH score and Gartland and Werley demerit criteria.

A total of 40 subjects with mean age of 36.43 ± 10.59 years, ranged from 20 to 58 years. Majority of the study subjects were males (75%) and females were 25%. RTA was the major cause of injury in 77.50% and fall from height in 22.50%. nearly 60% had right side injury and 40% had left side injury. Based on Gartland and Werley outcome, majority (65%) of the study population to have excellent outcome, 30% had good outcome and only 5% had fair outcome. 30(75%) patients had insignificant residual deformity and 10(25%) had slight deformity. Among the study population, 22(55%) had good radiological outcome, 11(27.50%) had excellent outcome and 7(17.50%) had fair outcome. The complications recorded was least. The mean DASH score with in radiologically good outcome was 12.94 ± 5.32, it was 13.09 ± 5.41 excellent and it was 18.66 ± 6.05 in fair. Taking radiologically good outcome as base line, the mean difference of DASH score (0.15) in excellent was statistically not significant (P value 0.939) and in fair (5.72) was statistically significant (P value 0.021).

The Mean Gartland and Werley demerit criteria score with in radiologically good outcome was 2.32 ± 1.55, it was 1.82 ± 2.48 excellent and it was 5.43 ± 2.7 in fair. Taking radiologically good outcome as base line, the mean difference of Gartland and Werley demerit criteria score (0.50) in excellent outcome was statistically not significant (P value 0.514) and in fair (3.11) was statistically significant (P value 0.001).

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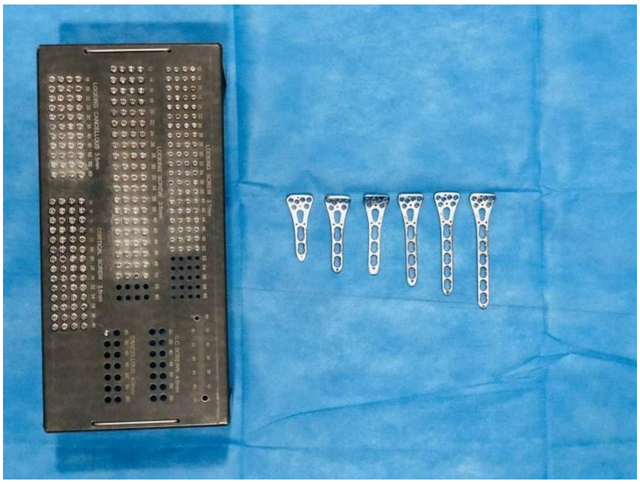
ANNEXURE

ANNEXURE - I

VARIABLE LOCKING PLATE: INSTRUMENTS



CASE 12


M
26-Sep-2020
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Im: 1002/1
Lat/Pos: -
R
R.L.JALAPPA HOSPITAL & RES...
DFOV: 25.1 x 30.2 cm
Zoom: 1.00x
CRTLUT (Data) [C:100.00...


M
26-Sep-2020
Acq: 20:20:00.651
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Lat/Pos: -
R
ru0
R.L.JALAPPA HOSPITAL & RES...
DFOV: 25.1 x 30.2 cm
Zoom: 1.00x
CRTLUT (Data) [C:100.00...


16-Sep-2021
Acq: 16:23:50.263
Se: -
Im: 1002/1
Lat/Pos: -
R
ru0


R
R.L.JALAPPA HOSPITAL &
00x
:2048 (Auto)

CASE 26

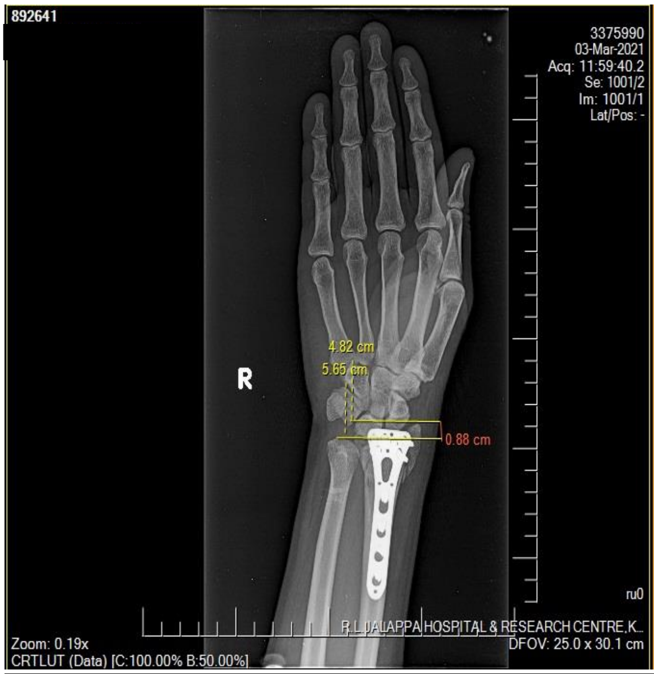

R


R


M
R
10-Apr-2020
Acq: 10:12:52.933
Se: -
Im: 1001
Lat/Pos: -
ru0
R.L.JALAPPA HOSPITAL & RESE...
DFOV: 25.1 x 30.2 cm
Zoom: 1.00x
CRTLUT (Data) [C:100.00...


M
R
Zoom: 1.00x
CRTLUT (Data) [C:100.0...

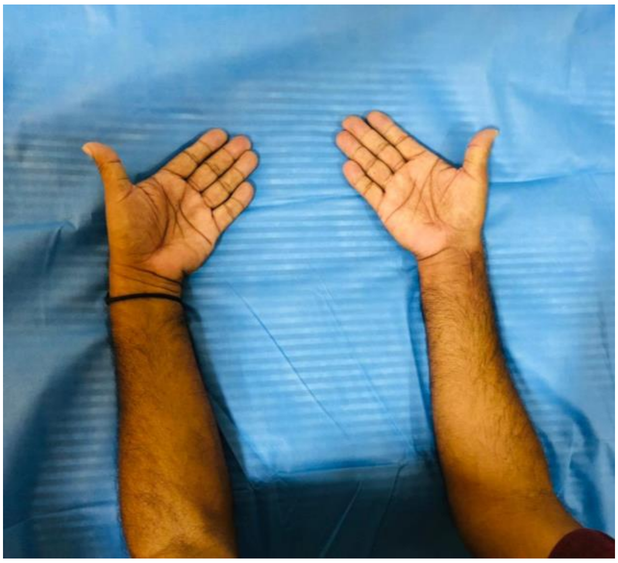
RADIOLOGICAL ASSESSMENT



C ARM PICS

RANGE OF MOTION

CASE 12



CASE 26

ANNEXURE – II

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR - 563101.

INFORMED CONSENT FORM

Case no:

IP no:

TITLE

Evaluation of functional and radiological outcomes following management of Volar Barton fracture fixed with Variable Locking Plate

- I, ____ aged ____________ ,after being explained in my own vernacular language about the purpose of the study and the risks and complications of the procedure, hereby give my valid written informed consent without any force or prejudice favouring locking plate fixation which is an operation to be performed on me or _______ under any anaesthesia deemed fit. The nature and risks involved in the procedure (surgical and anaesthetical) have been explained to me to my satisfaction.

I have been explained in detail about the Clinical Research on "**Evaluation of functional and radiological outcomes following management of Volar Barton fracture fixed with Variable Locking Plate"** being conducted. *I have read the patient information sheet and I have had the opportunity to ask any question. Any question that I have asked, have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.* I hereby give consent to provide my history, undergo physical examination, undergo the injection/ operative procedure, undergo investigations and provide its results and documents etc to the doctor / institute etc.

For academic and scientific purpose, the operation / procedure, etc may be video graphed or photographed. All the data may be published or used for any academic purpose. I will not hold the doctors / institute etc responsible for any untoward consequences during the procedure / study.

A copy of this Informed Consent Form and Patient Information Sheet has been provided to the participant.

(Signature & Name of Pt. Attendant) (Signature/Thumb impression & Name of patient)

(Relation with patient)---------

Witness: ---------------------------

(Signature & Name of Research person /doctor)-------------

ತಿಳಿವಳಿಕೆಯಸಮ್ಮತಿನಮೂನೆ

ನಾನು, ____ ವಯಸ್ಸಿನ _____________, ನನ್ನ ಸ್ವಂತ ಭಾಷೆಯಲ್ಲಿ ವಿವರಿಸಲ್ಪಟ್ಟ ನಂತರ ಅಧ್ಯಯನದ ಉದ್ದೇಶ ಮತ್ತು ಕಾರ್ಯ ವಿಧಾನದತೊಂದರೆಗಳು ಮತ್ತು ತೊಡಕುಗಳ ಬಗ್ಗೆ ವಿವರಿಸಿದ ನಂತರ, ಮುಚ್ಚಿದ ಕಡಿ ತಮತ್ತು ಆಂತರಿಕ ಸ್ಥಿರೀಕರಣ / ಓಪನ್ಗೆಯಾವು ದೇಬಲದ ಅಥವಾ ಪೂರ್ವಾಗ್ರಹವಿಲ್ಲದೆ ನನ್ನ ಮಾನ್ಯ ವಾದಲಿಖಿತ ವಿರೋಧಿ ಸಮ್ಮತಿಯನ್ನುನೀಡಿ ನನ್ನಮೇಲೆ ನಡೆಸಬೇಕಾದ ರೋಗ ನಿದಾನ ಮತ್ತು / ಅಥವಾ ಚಿಕಿತ್ಸ ಕಪ್ರಕ್ರಿಯೆ / ವರ್ಗಾವಣೆ / ಕಾರ್ಯಾಚರಣೆ ಅಥವಾ ಯಾವುದೇ ಅರಿವಳಿಕೆ ಅಡಿಯಲ್ಲಿ ನಂತಹ ಪ್ಲೇಟ್ಮ್ ತ್ತುತಿರುಪು / ಸಂಪ್ರದಾಯವಾದಿ ನಿರ್ವಹಣೆಯೊಂದಿಗೆ ಪ್ಲೇಟ್ಮತ್ತುಸ್ಕ್ರೂ / ಸಂಪ್ರದಾಯವಾದಿ ನಿರ್ವಹಣೆಗೆ ಒಳಪಡಿಸುವುದು ಯೋಗ್ಯವಾದವು. ಕಾರ್ಯ ವಿಧಾನದಲ್ಲಿ (ಶಸ್ತ್ರ ಚಿಕಿತ್ಸಾ ಮತ್ತು ಅನಾಸ್ಥೆಟಿಕಲ್) ಒಳಗೊಂಡಿರುವ ಸ್ವಭಾವ ಮತ್ತುಅಪಾಯಗಳು ನನ್ನತೃ ಪ್ತಿಗೆನನಗೆ ವಿವರಿಸಲಾಗಿದೆ.“ಓಲಾ ಬಾರ್ಟನ್ ಅಸ್ಥಭಂಗವನ್ನು ಬದಲಾಯಿಸಬಹುದಾದ ತಗಡುವಿನಿಂದಸ್ಥಿರವಾಗಿ ಬಿಗಿಗೊಳಿಸುವಶಸ್ತ್ರ ಚಿಕಿತ್ಸೆಯಕ್ರಿ ಯಾತ್ಮಕಮತ್ತುವಿಕಿರಣಶಾಸ್ತ್ರದಫಲಿತಾಂಶಗಳ”ಬಗ್ಗೆಒಂದುಅಧ್ಯಯನಕುರಿತುಕ್ಲಿನಿಕಲ್ರಿಸರ್ಚ್ಕುರಿತುನಾನುವಿವರಿಸಿದ್ದೇನೆ. ನಾನು ರೋಗಿಯ ಮಾಹಿತಿ ಹಾಳೆಯನ್ನು ಓದಿದ್ದೇನೆ ಮತ್ತು ಯಾವುದೇ ಪ್ರಶ್ನೆ ಕೇಳಲು ನನಗೆ ಅವಕಾಶವಿದೆ. ನಾನು ಕೇಳಿದಯಾವುದೇ ಪ್ರಶ್ನೆಯನ್ನು ನನ್ನ ತೃಪ್ತಿಗೆ ಉತ್ತರಮಾಡಲಾಗಿದೆ. ಈಸಂಶೋಧನೆಯಲ್ಲಿ ಪಾಲ್ಗೊಳ್ಳುವವರಾಗಿ ಭಾಗವಹಿಸಲು ನಾನು ಸ್ವಯಂಪ್ರೇರಣೆಯಿಂದ ಸಮ್ಮತಿಸುತ್ತೇನೆ. ನನ್ನ ಇತಿಹಾಸವನ್ನು ಒದಗಿಸಲು, ದೈಹಿಕಪರೀಕ್ಷೆಗೆ ಒಳಗಾಗಲು, ಇಂಜೆಕ್ಷನ್ಪ್ರಕ್ರಿಯೆಗೆ ಒಳಗಾಗಲು, ತನಿಖೆಗೆ ಒಳಗಾಗಬೇಕುಮತ್ತು ಅದರ ಫಲಿತಾಂಶಗಳು ಮತ್ತುದಾಖಲೆಗಳನ್ನು ವೈದ್ಯರಿಗೆ /ಇನ್ಸ್ಟಿಟ್ಯೂಟ್ಗೆನೀಡುವಂತೆ ನಾನು ಒಪ್ಪಿಗೆ ನೀಡುತ್ತೇನೆ.

ಶೈಕ್ಷಣಿಕ ಮತ್ತು ವೈಜ್ಞಾನಿಕ ಉದ್ದೇಶಕ್ಕಾಗಿ ಕಾರ್ಯಾಚರಣೆ / ವಿಧಾನ, ಇತ್ಯಾದಿ ವೀಡಿಯೊವನ್ನು ಗ್ರಾಂಪ್ಡ್ ಅಥವಾ ಛಾಯಾಚಿತ್ರ ಮಾಡಬಹುದು. ಎಲ್ಲಾ ಡೇಟಾವನ್ನು ಯಾವುದೇ ಶೈಕ್ಷಣಿಕ ಉದ್ದೇಶಕ್ಕಾಗಿ ಪ್ರಕಟಿಸಬಹುದು ಅಥವಾ ಬಳಸಬಹುದು. ಕಾರ್ಯವಿಧಾನ / ಅಧ್ಯಯನದ ಸಮಯದಲ್ಲಿ ಯಾವುದೇ ಕೆಟ್ಟ ಪರಿಣಾಮಗಳಿಗೆ ನಾನು ವೈದ್ಯರು / ಇನ್ಸ್ಟಿಟ್ಯೂಟ್ ಇತ್ಯಾದಿಗಳನ್ನು ಹೊಂದುವುದಿಲ್ಲ.

ಈ ಮಾಹಿತಿಯುಕ್ತ ಸಮ್ಮತಿಯ ಫಾರ್ಮ್ಮ ತ್ತುರೋಗಿಯ ಮಾಹಿತಿ ಹಾಳೆಯನ್ನು ಪ್ರತಿಸ್ಪರ್ಧಿಗೆ ಒದಗಿಸಲಾಗಿದೆ.

(ರೋಗಿಯಪರಿಚಾರಕನಸಹಿ&ಹೆಸರು) (ರೋಗಿಯ / ಗಾರ್ಡಿಯನ್ನಸಹಿ / ಹೆಬ್ಬೆಟ್ಟಿನಗುರುತು&ಹೆಸರು)

(ರೋಗಿಯಸಂಬಂಧ)

(ಸಂಶೋಧಕನ /ವೈದ್ಯರಸಹಿ&ಹೆಸರು)

PATIENT INFORMATION SHEET

STUDY TITLE: "Evaluation of functional and radiological outcomes following management of Volar Barton fracture fixed with Variable Locking Plate"

Study location: R L Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar.

Details- Patients presenting with isolated Volar Barton fracture in the Emergency department of R.L.J. HOSPITAL AND RESEARCH CENTRE, attached to SRI DEVARAJ URS MEDICAL COLLEGE, TAMAKA, KOLAR

Patients in this study will have to undergo routine blood investigations (CBC, RFT, serum electrolytes, blood grouping, HIV& HBsAG), chest x ray, ECG and x-ray of wrist with forearm–AP and lateral view

Please read the following information and discuss with your family members. You can ask any question regarding the study. If you agree to participate in the study we will collect information (as per proforma) from you or a person responsible for you or both. Relevant history will be taken. This information collected will be used only for dissertation and publication.

All information collected from you will be kept confidential and will not be disclosed to any outsider. Your identity will not be revealed. This study has been reviewed by the Institutional Ethics Committee and you are free to contact the member of the Institutional Ethics Committee. There is no compulsion to agree to this study. The care you will get will not change if you don't wish to participate. You are required to sign/ provide thumb impression only if you voluntarily agree to participate in this study.

CONFIDENTIALITY

Your medical information will be kept confidential by the study doctor and staff and will not be made publicly available. Your original records may be reviewed by your doctor or ethics review board. For further information/ clarification please contact

Dr.KARTHIK.S.J (Post Graduate),

Department of Orthopaedics,

SDUMC, Kolar

CONTACT NO: 9791300599

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR - 563101.

PROFORMA

<u>Case no</u>:

<u>IP no</u>:

TITLE:
"EVALUATION OF FUNCTIONAL AND RADIOLOGICAL OUTCOMES FOLLOWING MANAGEMENT OF VOLAR BARTON FRACTURE FIXED WITH VARIABLE LOCKING PLATE"

1. BASIC DATA

Name Age/Sex

Address

Mobile No.

Date of Procedure

Date of Admission/OP

Date of Discharge

History:

Mechanism of injury:

General physical examination:

Vitals: Pulse- B.P-

RR- Temp-

Systemic examination:

CVS-

RS-

PS-

CNS-

Pre-existing systemic illness:

Diabetes/Thyroid disorder/ Cervical Spine/ CVS/RS/ CNS/locomotor/ TB/ anaemia/ Hypertension/ malnutrition/others

Local examination:

Side	: Left/Right/Bilateral
Deformity	: Present/Absent
Swelling	: Present/Absent
Tenderness	: Present/Absent
ROM @ wrist	: Full / Restricted
Distal sensation	: Present/Absent
Distal pulsation	: Palpable/Absent

2. **DIAGNOSIS**:

3. **INVESTIGATIONS**:

CBC, BT, CT

Blood urea, serum creatinine, RBS

Serum electrolytes

RBS

X ray wrist :

4. TREATMENT:

OPERATIVE TREATMENT: VARIABLE LOCKING PLATING

Operation on –

3. **POST PROCEDURE**

Observation in surgical ICU

Immobilization of arm

NSAIDS

Antibiotics Prophylactic/therapeutic/Nil

Systemic complications

Bleeding, infection, neurovascular injury, shock, ICU admission, malunion, non-union

Local complications

1. Necrosis of skin
2. Infection: a) suspected/established

   b) superficial/deep

   c) mild/moderate/severe
3. Hematoma
4. Others

Further treatment of complications

None/Hematoma aspirated/open dressing/debridement/suction irrigation/plastic procedure/Physiotherapy

6. TIME OF DISCHARGE

ROM assessment

Overall functional assessment according to Gartland and Werley demerit criteria and DASH Score

Complications

1. Systemic: healed/improved/unchanged/dies/nil
2. Local: healed/improved/unchanged/nil

RANGE OF MOTION:

MOVEMENT	
FLEXION	
EXTENSION	
RADIAL DEVIATION	
ULNAR DEVIATION	
SUPINATION	
PRONATION	

DASH SCORE:

DISABILITIES OF THE ARM, SHOULDER AND HAND

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. Open a tight or new jar.	1	2	3	4	5
2. Write.	1	2	3	4	5
3. Turn a key.	1	2	3	4	5
4. Prepare a meal.	1	2	3	4	5
5. Push open a heavy door.	1	2	3	4	5
6. Place an object on a shelf above your head.	1	2	3	4	5
7. Do heavy household chores (e.g., wash walls, wash floors).	1	2	3	4	5
8. Garden or do yard work.	1	2	3	4	5
9. Make a bed.	1	2	3	4	5
10. Carry a shopping bag or briefcase.	1	2	3	4	5
11. Carry a heavy object (over 10 lbs).	1	2	3	4	5
12. Change a lightbulb overhead.	1	2	3	4	5
13. Wash or blow dry your hair.	1	2	3	4	5
14. Wash your back.	1	2	3	4	5
15. Put on a pullover sweater.	1	2	3	4	5
16. Use a knife to cut food.	1	2	3	4	5
17. Recreational activities which require little effort (e.g., cardplaying, knitting, etc.).	1	2	3	4	5
18. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	1	2	3	4	5
19. Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.).	1	2	3	4	5
20. Manage transportation needs (getting from one place to another).	1	2	3	4	5
21. Sexual activities.	1	2	3	4	5

DISABILITIES OF THE ARM, SHOULDER AND HAND

	NOT AT ALL	SLIGHTLY	MODERATELY	QUITE A BIT	EXTREMELY
22. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups? *(circle number)*	1	2	3	4	5

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
23. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem? *(circle number)*	1	2	3	4	5

Please rate the severity of the following symptoms in the last week. *(circle number)*

	NONE	MILD	MODERATE	SEVERE	EXTREME
24. Arm, shoulder or hand pain.	1	2	3	4	5
25. Arm, shoulder or hand pain when you performed any specific activity.	1	2	3	4	5
26. Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4	5
27. Weakness in your arm, shoulder or hand.	1	2	3	4	5
28. Stiffness in your arm, shoulder or hand.	1	2	3	4	5

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
29. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? *(circle number)*	1	2	3	4	5

	STRONGLY DISAGREE	DISAGREE	NEITHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
30. I feel less capable, less confident or less useful because of my arm, shoulder or hand problem. *(circle number)*	1	2	3	4	5

DASH DISABILITY/SYMPTOM SCORE = _____ ([(sum of n responses / n) - 1] x 25, where n is the number of completed responses.)

A DASH score may not be calculated if there are greater than 3 missing items.

SCORE:

GARTLAND AND WERLEY DEMERIT CRITERIA

Results	Point
Residual deformity (range, 0 to 3 points)	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	2 or 3
Subjective evaluation (range, 0 to 6 points)	
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 disability if careful, and activities slightly restricted	4
Poor: pain, limitation of motion, disability, and activities more or less markedly restricted	6
Objective evaluation* (range, 0 to 5 points)	
Loss of extension	5
Loss of ulnar deviation	3
Loss of supination	2
Loss of flexion	1
Loss of radial deviation	1
Loss of circumduction	1
Pain in distal radio-ulnar joint	1
Grip strength: 60% or less than on the opposite side†	1
Loss of pronation†	2
Complications (range, 0 to 5 points)	
Arthritic change	
Minimum	1
Minimum with pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complications (median)	1–3
Poor finger function due to cast	1 or 2
Final results (ranges of points)	
Excellent	0–2
Good	3–8
Fair	9–20
Poor	≥ 21

SCORE:

SARMIENTO MODIFICATION OF LINDSTROM CRITERIA

	Residual deformity	Loss of palmar tilt (°)	Radial shortening (mm)	Loss of radial deviation (°)
Excellent				
Good				
Fair				
Poor				

OUTCOME:

KEY TO MASTER CAHRT:

A= Serial number

B= Age

C= Sex

D=UHID

E=Mode of Injury

F= Side

G= Flexion

H= Extension

I= Radial deviation

J= Ulnar deviation

K= Supination

L= Pronation

M= DASH score

N= Gartland Werley Demerit criteria score

O= Gartland Werley Outcome

P= Residual deformity

Q= Loss of palmar tilt

R= Radial shortening

S= Loss of radial inclination

T= Sarmiento Modification of Lindstrom criteria outcome

U= Complications

MASTER CHART

S.No	AGE	SEX	UHID	MODE OF INJURY	SIDE	FLEXION	EXTENSION	RADIAL DEVIATION	ULNAR DEVIATION	SUPINATION	PRONATION	DASH SCORE	GARTLAND AND WERLEY DEMERIT CRITERIA SCORE	G.W. OUTCOME	RESIDUAL DEFORMITY	LOSS OF PALMAR TILT	RADIAL SHORTENING	LOSS OF RADIAL INCLINATION	LINDSTORM CRITERIA OUTCOME	COMPLICATION
1	25	M	736395	RTA	LEFT	75	78	10	30	80	78	17.2	4	GOOD	INSIGNIFICANT	4	4	5	GOOD	SUPERFICIAL INFECTION
2	25	F	808626	RTA	LEFT	70	76	12	30	82	80	10	2	EXCELLENT	INSIGNIFICANT	3	4	6	GOOD	NIL
3	20	M	768361	RTA	LEFT	75	75	10	28	85	80	11	2	EXCELLENT	INSIGNIFICANT	0	2	4	EXCELLENT	NIL
4	40	M	799211	RTA	LEFT	65	70	10	25	75	75	18.6	5	GOOD	SLIGHT	11	4	10	FAIR	NIL
5	38	M	843058	FALL FROM HEIGHT	RIGHT	70	72	8	25	78	75	10	1	EXCELLENT	INSIGNIFICANT	0	3	0	EXCELLENT	NIL
6	34	M	842350	RTA	RIGHT	65	70	11	30	80	78	18.4	3	GOOD	INSIGNIFICANT	5	3	6	GOOD	SUPERFICIAL INFECTION
7	38	M	771354	RTA	RIGHT	70	73	12	32	82	76	10	1	EXCELLENT	INSIGNIFICANT	0	2	4	EXCELLENT	NIL
8	24	M	799178	FALL FROM HEIGHT	LEFT	65	70	8	28	78	72	18	4	GOOD	SLIGHT	10	7	10	FAIR	NIL
9	31	M	728676	RTA	RIGHT	75	76	10	30	80	76	10	1	EXCELLENT	INSIGNIFICANT	5	4	6	GOOD	NIL
10	40	F	798772	FALL FROM HEIGHT	LEFT	74	80	12	32	80	75	12	1	EXCELLENT	INSIGNIFICANT	0	2	4	EXCELLENT	NIL
11	34	M	801561	RTA	RIGHT	76	78	12	30	84	78	12	0	EXCELLENT	INSIGNIFICANT	6	4	7	GOOD	NIL
12	28	M	852167	RTA	RIGHT	68	70	12	32	80	75	18	5	GOOD	INSIGNIFICANT	5	5	5	GOOD	NIL
13	30	M	825805	FALL FROM HEIGHT	RIGHT	70	72	10	28	78	76	15	2	EXCELLENT	INSIGNIFICANT	6	5	6	GOOD	NIL
14	29	M	843286	RTA	LEFT	65	68	10	28	75	77	14	2	EXCELLENT	INSIGNIFICANT	4	4	6	GOOD	NIL
15	38	M	863136	RTA	RIGHT	70	72	11	30	75	72	13	1	EXCELLENT	INSIGNIFICANT	0	2	4	EXCELLENT	NIL
16	28	M	868643	RTA	RIGHT	65	68	8	30	78	78	19	6	GOOD	SLIGHT	12	7	12	FAIR	HYPERTROPHIC SCAR
17	28	M	873964	RTA	LEFT	70	72	10	32	80	76	12	2	EXCELLENT	INSIGNIFICANT	5	5	6	GOOD	NIL
18	58	F	874802	RTA	LEFT	68	70	12	25	76	74	15	5	GOOD	SLIGHT	5	5	7	GOOD	NIL
19	38	M	877688	FALL FROM HEIGHT	RIGHT	72	74	12	35	80	78	10	1	EXCELLENT	SLIGHT	11	7	10	FAIR	NIL
20	39	M	855250	RTA	LEFT	68	70	10	32	75	72	20	6	GOOD	SLIGHT	7	5	8	GOOD	NIL
21	41	M	879363	RTA	LEFT	75	75	10	30	80	76	8	0	EXCELLENT	INSIGNIFICANT	0	2	3	EXCELLENT	NIL
22	25	M	888728	FALL FROM HEIGHT	RIGHT	70	70	8	32	82	76	10	1	EXCELLENT	INSIGNIFICANT	7	4	7	GOOD	NIL
23	48	M	879406	RTA	RIGHT	75	75	11	35	85	80	11	2	EXCELLENT	INSIGNIFICANT	6	3	6	GOOD	NIL
24	48	F	893158	RTA	RIGHT	78	80	12	28	78	76	12	2	EXCELLENT	INSIGNIFICANT	5	4	5	GOOD	NIL
25	58	M	892641	RTA	RIGHT	70	75	8	30	80	74	14	1	EXCELLENT	INSIGNIFICANT	0	1	3	EXCELLENT	NIL
26	32	F	896276	RTA	RIGHT	68	70	6	32	84	78	20	6	GOOD	SLIGHT	10	7	12	FAIR	COMPLEX REGIONAL PAIN SYNDROME
27	23	M	895001	RTA	RIGHT	75	78	11	35	80	78	12	1	EXCELLENT	INSIGNIFICANT	2	5	5	GOOD	NIL
28	48	M	898846	FALL FROM HEIGHT	RIGHT	70	73	8	30	78	76	10	0	EXCELLENT	INSIGNIFICANT	0	1	3	EXCELLENT	NIL
29	55	F	899261	RTA	RIGHT	68	72	10	30	78	75	15	2	GOOD	INSIGNIFICANT	6	5	6	GOOD	NIL
30	51	F	889082	RTA	LEFT	70	74	11	35	80	76	12	2	EXCELLENT	INSIGNIFICANT	0	2	2	EXCELLENT	NIL
31	36	M	800928	RTA	RIGHT	75	75	10	38	82	78	5	2	EXCELLENT	SLIGHT	5	4	6	GOOD	NIL
32	52	M	899077	RTA	LEFT	68	78	11	30	78	75	28	9	FAIR	INSIGNIFICANT	0	2	3	EXCELLENT	NIL
33	51	M	906079	FALL FROM HEIGHT	RIGHT	76	80	12	28	82	76	18	2	EXCELLENT	INSIGNIFICANT	4	4	5	GOOD	NIL
34	44	F	908089	RTA	LEFT	70	80	12	38	82	78	16	2	EXCELLENT	INSIGNIFICANT	0	1	4	EXCELLENT	NIL
35	32	M	908341	RTA	RIGHT	68	76	10	28	78	75	25	4	GOOD	SLIGHT	5	4	6	GOOD	NIL
36	35	F	925072	FALL FROM HEIGHT	RIGHT	68	78	8	30	82	78	5	1	EXCELLENT	INSIGNIFICANT	2	5	7	GOOD	NIL
37	23	M	928476	RTA	LEFT	75	80	10	35	83	76	5	1	EXCELLENT	INSIGNIFICANT	5	4	7	GOOD	NIL
38	42	F	856218	RTA	LEFT	70	78	8	32	80	78	15	6	GOOD	SLIGHT	11	7	12	FAIR	HYPERTROPHIC SCAR
39	23	M	928476	RTA	RIGHT	68	75	10	25	78	75	30	10	FAIR	INSIGNIFICANT	11	7	12	FAIR	NIL
40	25	M	946277	RTA	RIGHT	72	76	10	30	82	76	5	1	EXCELLENT	INSIGNIFICANT	6	4	6	GOOD	NIL