COMPARATIVE STUDY ON THE ANALYSIS OF FUNCTIONAL OUTCOME IN DISTAL RADIUS ARTICULAR FRACTURES TREATED BY CLOSED REDUCTION THROUGH BRIDGING EXTERNAL FIXATOR AUGMENTED WITH K-WIRES AND VOLAR-LOCKING PLATING

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ORTHOPAEDIC SURGERY

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CERTIFICATE

This is to certify that this dissertation titled **"COMPARATIVE STUDY ON THE ANALYSIS OF FUNCTIONAL OUTCOME IN DISTAL RADIUS ARTICULAR FRACTURES TREATED BY CLOSED REDUCTION THROUGH BRIDGING EXTERNAL FIXATOR AUGMENTED WITH K-WIRES AND VOLAR-LOCKING PLATING"** is a bonafide record of work done by **DR. KEERTHY CHANDRA BASSETTY,** during the period of his postgraduate study from July 2012 to September 2014 under guidance and supervision in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-600003, in partial fulfillment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree Examination of The Tamilnadu Dr. M.G.R. Medical University to be held in April 2015.

PROF.N.DEEN MUHAMAD ISMAIL.
Director I/C
Institute of Orthopaedics andTraumatology
Madras Medical College &
RajivGandhi GovernmentGeneral Hospital,
Chennai – 600 003

DR. R.VIMALA
Dean
Madras Medical College &
Rajiv GandhiGovernment
General Hospital
Chennai -600 003

DECLARATION

I declare that the dissertation entitled **"COMPARATIVE STUDY ON THE ANALYSIS OF FUNCTIONAL OUTCOME IN DISTAL RADIUS ARTICULAR FRACTURES TREATED BY CLOSED REDUCTION THROUGH BRIDGING EXTERNAL FIXATOR AUGMENTED WITH K-WIRES AND VOLAR-LOCKING PLATING** *" submitted by me for the degree of M.S is the record work carried out by me during the period of* ***July 2012 to September 2014*** *under the guidance of* ***PROF.N.DEEN MUHAMMAD ISMAIL,*** **M.S.ORTHO., D.Ortho.,** *Professor of Orthopaedics, Institute of Orthopaedics and Traumatology, Madras Medical College, Chennai. This dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfillment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2015.*

Place: Chennai **Signature of the Candidate**
Date: **(Dr. KEERTHY CHANDRA BASSETTY)**

Signature of the Guide
Prof. ***N.DEEN MUHAMMAD ISMAIL*** **M.S.Ortho., D.Ortho.,.**
Director I/C
Institute of Orthopaedics and Traumatology,
Madras Medical College, Chennai.

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COMPARATIVE STUDY ON THE ANALYSIS OF FUNCTIONAL OUTCOME IN DISTAL RADIUS ARTICULAR FRACTURES TREATED BY CLOSED REDUCTION THROUGH BRIDGING EXTERNAL FIXATOR AUGMENTED WITH K-WIRES AND VOLAR-LOCKING PLATING

KEERTHY CHANDRA BASSETTY

ABSTRACT

KEYWORDS: distal radius, articular fractures, external fixator, k-wires, volar LCP, 2- column LCP, Lindstorm's criteria, functional assessment, Mayo wrist score

PURPOSE:

The purpose of this study was to compare the functional outcome in distal radius articular fractures treated by closed reduction through bridging external fixator augmented with k-wires and volar-locking plating.

METHODS:

This study included patients with comminuted unstable intra-articular distal radius fractures treated at Rajiv Gandhi Govt. General Hospital. 27 patients treated with either modality of treatment were analysed, who had been followed up for an average of was 8.9 months, (range : 3 months to 24 months). Prospective and retrospective data were gathered on patients, of which 15 were treated with external fixator augmented with k-wire and 12 were treated with 2- column fixed-

angle volar LCP . The 2 groups were compared for range of motion (ROM), strength, and functional outcome as measured by the Mayo wrist score. Fracture reduction was evaluated from radiographs taken at the last follow-up visit and compared between groups. Sarmiento's modification of Lindstorm's criteria was used to compare the radiological outcome in both the groups.

RESULTS:

The mean passive wrist ROM at the final follow-up evaluation in ext fixation patients was 55 degrees extension and 67 degrees flexion, compared with 69 degrees extension and 77 degrees flexion in patients treated with volar LCP group. Whereas mean passive wrist ROM at the final follow-up evaluation in ext fixation patients was 58 degrees supination and 46 degrees pronation, compared with 76 degrees supination and 64 degrees pronation in patients treated with volar LCP group. Final radiographic measurements for the Ext fixation group averaged 2.9 degrees volar tilt and 14.2 mm degrees radial inclination, with 5mm radial length. The Volar LCP group averaged 7.3 degrees volar tilt, 16.9 degrees radial inclination, with 9.75mm radial length. Radial length and volar tilt were significantly greater for the ORIF group when compared with the radial length. There was significant difference in the radiological and functional outcome of AO Muller type C fractures treated by volar LCP with respect to the external fixator group (p value 0.009 and 0.026 respectively). There was no significant difference in the radiological and functional outcome of AO Muller type B fractures treated by volar LCP with respect to the external fixator group (p value 0.706 and 0.707 respectively).

CONCLUSION:

The use of ORIF with a volar fixed-angle implant resulted in stable fixation of the unstable (dorsally or volarly displaced intraarticular) distal articular fragments, allowing early postsurgical wrist motion (functional outcome) and having excellent to good radiological outcome. The fracture fixation with volar plate and screw system in the management of distal radius articular fractures, especially in type C (Complete intraarticular fractures) is a superior method to maintain the reduction till union and prevent the collapse of the fracture fragments, even in grossly comminuted , unstable and osteoporotic bones ; as compared with external fixator augmented with K – wires. However in type B (partial intraarticular fractures) fractures, Volar LCP and K- wire augmented External fixator provide equivocal results and none is proved superior. Ligamentotaxis by external fixation provided favourable results in younger age group and in partial intra- articular type of distal radius fractures and requires atleast 4 cortical purchases on each side for effective stability. However long term follow-up is required to confirm our findings

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INTRODUCTION

Distal radius fractures are most common fractures of upper limb presenting at emergency rooms, compromising of more than 16% of all fractures. Distal radial fractures have a bimodal type of age distribution with high-energy trauma contributing in younger and low energy trauma in elderly population. Females are more liable to distal radius fractures when compared with males[1] mainly because of more severe osteoporosis and a higher liability of elderly women to falls[2] compared to the age - matched men.

The metaphyseal widening of the distal radius is a zone predisposed to fractures because of a lower amount of strong cortical bone and higher amount of weaker cancellous bone. The major risk factors are low bone mineral density (BMD) and a tendency to fall. Consequently, a fracture of the distal radius is typically theresult of a fall on the outstretched arm in a postmenopausal woman, where a functionally active person suffers a trauma on an osteoporotic bone.

Until about 60 years ago, it was general notion that most distal radial fractures could be treated conservatively with satisfactory results. Only

recently, it was clinically proved that intra-articular step-off and radial shortening corrected by surgery had improved patient outcome [3,4]. These issuesdon't affect elderly people and low-demand patients probably due to low functional and physical demand. In general anatomic reduction should be pursued in younger and high-demand elderlypatients (because of longer healing time and to initiate early mobilization) with extra-articular fracture or intra-articular fractures. Low-demand elders with severely displaced intra-articular fracture or median nerve compression require surgical management but otherwise the prime focus in this group should be on joint movement [3;4].

Non-displaced or reducible but stable extra and intra-articular fractures can also be treated with casting. Unstable reducible extra-articular fractures are commonly treated with reduction and often supplemented with extra- or intra-focal pinning. Extra-articular fractures that are irreducible, intraarticular fractures and fractures for demanding patients who require early mobilization, are commonly treated with plating (more often with palmar plating), intramedullary fixation, external fixation or pinning [5;6;7;8].

Close reduction and cast immobilization has been the principal mode of management of distal radius fractures but it often lead to fracture malunion and subluxation /dislocation of distal radioulnar joint, hence resulting in poor functional, radiographic and cosmetic results[9]. The residual worse deformity

of wrist adversely affected wrist motion and hand function, thereby interfering with the mechanical advantage of the extrinsic hand musculature[10].It also causes pain, limitation of forearm motion, and decreased grip strength as a result of arthrosis of the radiocarpal and distal radioulnar joints[11].

Open reduction and volar plating was designed to ensure more consistent correction of displacement and maintenance of reduction. Metaphyseal defects can also be grafted, although not generally advocated in fresh fractures and good bone quality[12].

AIM OF THE STUDY

To analyze and compare the functional outcome in distal radius articular fractures of 27 patients treated by closed reduction through bridging external fixator augmented with K-wires and volar-locking plating done in our Institute of Orthopaedics and Traumatology, Madras Medical College and Rajiv Gandhi Government General Hospital over a period of 2 years and 2 months from July 2012 to September 2014.

We evaluated the efficiency of the fixation with volar locking compression plate with bridging external-fixator optionally augmented with k-wires for distal radius articular fractures by

1) Radiographic assessment of post- operative fixation
2) Functional assessment of post- operative fixation
3) Evaluation of treatment related complications

HISTORICAL REVIEW

Fractures of the distal radius have been reviewed in literature forover centuries.

Hippocrates in the early eighteenth century, diagnosedany displacement of the wrist following injury as dislocation due to theabsence of fracture character like crepitus, paradoxical mobility, edema etc.

Pouteau[13], in late 18th century, pointed out that the fractures of the distal end of radius were falsely diagnosed as wrist dislocations .

In 1814,**AbrahamColles**[14]described the dorsally displaced distal radius fracture that bears his name

In 1834,**Dupuytren**[15]showed that the majority of the distal radial injuries in doubt wereactually fractures,which were found to be displaced dorsally.

In 1838,**Barton**[16] defined the transected type of fracture due to acting force when the hand is at volar flexion, with the line ofthe fracture passes obliquely intraarticularly and the coronal split of the fractured fragment.

In 1847,**Smith**[17] defined fracture with anterior displacement, as a result of falling with the hand in volar flexion that was named after him and thence the volar displacement.

In 1915,**Jones**[18]enumerateda closed manipulation technique for reduction byincreasing the deformity, giving traction and immobilizing in reduced position.

In 1995,**Connolly**[19]reduced the fractures by reversing the original mechanismof injury.

In 1944,**Anderson and O'Niel**[20]described the principles of ligamentotaxis for the use of external fixators in distal radius fractures. The external fixator acts as a neutralization device and to maintain traction.

In 1950,**Charnley et al**[21]described three point contact for castimmobilization. The three points were dorsally over the dorsal fragment, volarly and dorsally over the forearm and volarly over the distal aspect ofproximal fragment.

In 1964,**Lambotte**[22]proposed pinning of radial styloid for maintaining purchase in distal radius fractures.

In 1965,**Ellis**[23]devised a technique of open reduction and internal fixation with T shaped plate for unstableSmith's or volar Barton fracture

In 1993,**Agee**[24]found that volar tilt is brought about by volar translation of the hand.

In 1967,**Frykman**[25]first described distal ulna fractures associated with distalradius fractures. He reported that fall on the outstretched hand with the

wristjoint in 40° to 90° of extension produces dorsally displaced distal radiusfracture. He established an eponymous classification system, which definesthe fracture as intra-articular or extra-articular. It also describes the involvement of radiocarpal and distal radioulnar joints along with the presence or absence of ulnar styloid process fracture.

In 1984,**Melone**[26]proposed a classification by describing four components of the radiocarpal joint and five patterns in intra articular fractures.

Sarmiento and associates[27]recommended plaster immobilization in supination, if distal radioulnar joint was found to be involved.

In 19,**Kapandji**[28]proposed two pin intrafocal pinning. This was utilized in DRUJ restoration and creation of pseudo joint in distal ulna.

In 1987,**Weber**[29]described the bending mechanism and its relation to the fracture pattern of the distal radius. He also stated that collapse of the fracture is unavoidable due to pull of flexor and extensor tendons.

In 1989,**John M. Rayhack**[30]proposed the technique of ulnar- radial wiring to immobilize the distal radio-ulnar joint supplementing the ligamentotaxis.

In 1989,**John K.Bradway**[31]retrospectively reviewed results in 16 patientstreated by open reduction and internal fixation and concluded that internalfixation is the treatment of choice for displaced, comminuted intra articularfractures.

In 1990,**Bartosh and Saldana**[32]stated that the technique of closed traction and reduction will not accurately restore palmar tilt due to thick palmar ligaments as compared to dorsal ligaments.

In 1990,**James Shaw et al**[33]conducted a biomechanical study and opined primary repair of displaced ulnar styloid avulsion fractures is essential for a stable distal radio ulnar joint.

In 1993,**Metz and Gilula**[34]stated that, all distal radius fractures should undergo postero-anterior and lateral view x-rays.

In 1996,**Rikkli**[36]described the three column concept of the wrist. He stated that the ulnar column serves as an axis of rotation for forearm and important load transmitter next to the middle column.

In 1997,**Louis W. Catalano III**[37]did a retrospective study to determine the long term functional and radiographic outcomes in a series of young adults treated with open reduction and internal fixation and concluded that outcome of a distal radial fracture is largely determined by its type.

In 1997,**Fitoussi F**[38]**,** in a study of 34 patients with intra-articular fractures of the distal radius treated with open reduction and internal fixation with buttress plate and screws, concluded that the potential for restoration of normal alignment and stability of fixation are the main advantages of internalfixation with plates.

In 1998,**Carter PR**[39]evaluated a new method of internal fixation of unstable distal radius fractures using an anatomically pre shaped, rigid dorsal low profile plate with recessed screw holes along with autogenous bone graft and concluded that patients with unstable fractures benefited with the new plate.

In 2000,**Jakob M**[40]conducted a study on 76 patients and recommended a double plating method with 2 mm titanium plates, for dorsally displaced fractures, where open reduction is indicated to restore congruency and extraarticular anatomy. It is reliable in providing stable internal fixation and allowing early function.

In 2004, **Louis W.Catalano**[41]assessed the articular displacements of distal radius fractures and stated that current operative indications include fractures with radiocarpal or distal radioulnar joint step or gap deformities greater than l-2mm, gross distal radioulnar joint instability or those with extensive metaphyseal comminution. In general, there is tendency to lean toward operative fixation in younger, more active patients.

Ring D et al[42]stated condylar blade plate fixation of unstable distal ulna fractures associated with distal radius fractures gave good alignment and satisfactory results.

In 2005,**Nana AD et a**[43]**l** gave guidelines for acceptable reduction with parameters including radial inclination, radial height, palmar tilt and articular incongruity.

In 2006,**Szabov**[44] stated that, in addition to the triangular fibrocartilage complex (TFCC), further stability to distal radio ulnar joint is provided by pronator quadratus, extensor carpi ulnaris, joint capsule and interosseous membrane.

In 2006, **Schnall Stephen B et al**[45]evaluated the advantages of newer methodof internal fixation with fracture specific implants and stated that theyprovided stable fixation with good functional outcome.

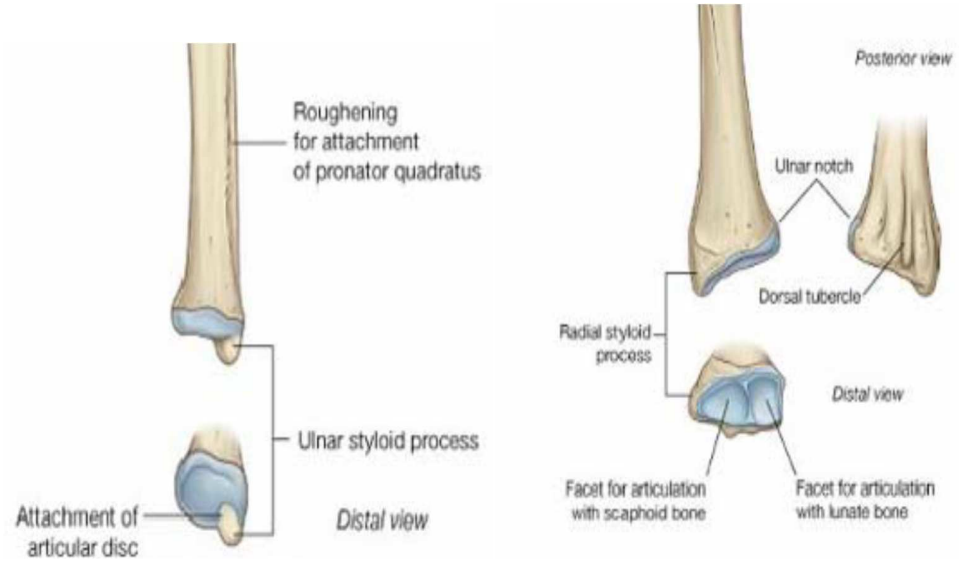
In 2007, **Rohit Arora et al**[46]analyzed internal fixation with 2.4 mm lockingcompression plate and claimed superior stability with maximum number of screws in metaphyseal segment.

In 2007, **Dennison DG**[47]Open reduction and internal locked plate fixation of distal radiusfracture gave good to excellent functional outcome score.

APPLIED ANATOMY

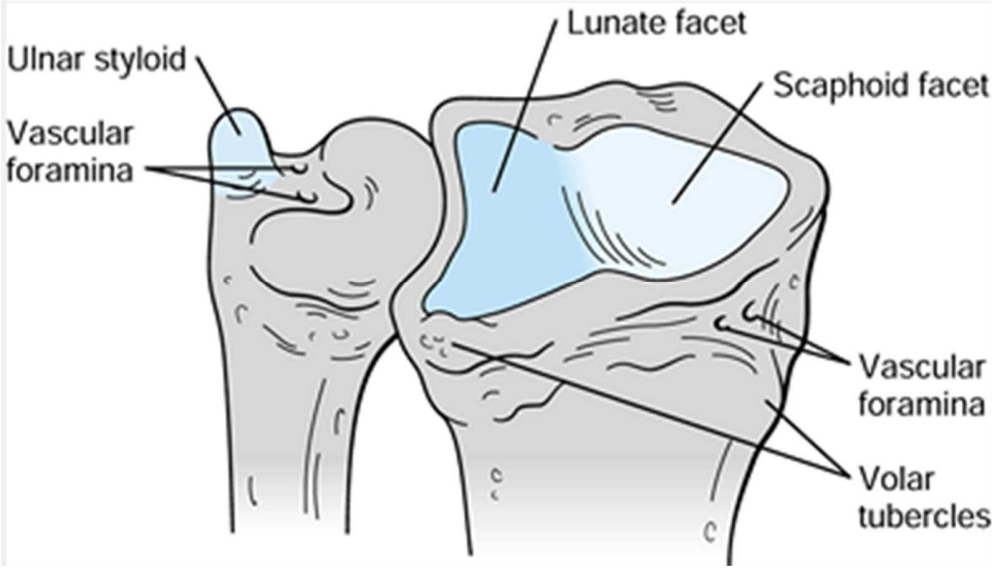
Wrist is derived from the latin word ‘WRAESTON’ meaning to twist. The articular joint of wrist joint includes distal end of radius(around 5 cm) , distal ulna andproximal row of carpus. It includes radiocarpal,ulno -carpal and distal radio ulnar joint.

Skeletal anatomy:



Skeletal anatomy of distal radius and distal ulna

The distal radius articular surface is made of hyaline cartilage. The distal articular surface of the radius is concave in both the saggital and coronal planes. The triangular configuration is inclined at an angle of 10 - 15º and 15 - 25º in the volar and ulnar planes respectively.

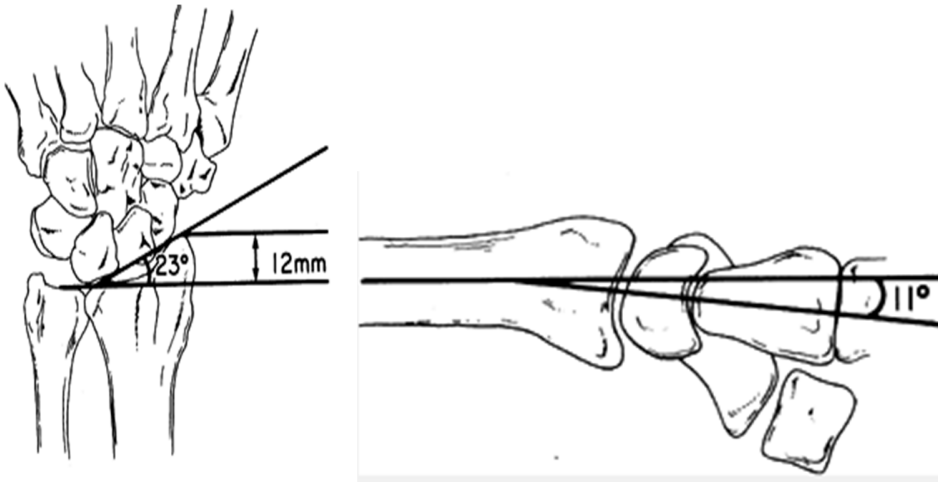


It is consisting of (a) Metaphysis, (b) Scaphoid facet, (c) Sigmoid notch, and (d) Lunate facet. An anteroposterior ridge divides the articular surface into a triangular lateral facetand quadrilateral medial facet, which articulates with the scaphoid and the lunaterespectively. The medial surface of the distal radius articulates with the ulna head with it's semicircular notch. This enables the radius to swing around its axis , the ulna. The prominent styloid process, is the main part of the flaring lateral process and it is the attachment to the brachioradialis muscle.

The distal radius interacts with the proximal surfaces of the scaphoid and lunate through the scaphoid fossa and the lunate fossa. Thetriangular scaphoid fossa points radially, and is much larger than the morequadrangular lunate fossa, which is located on the ulnar side of the radius.

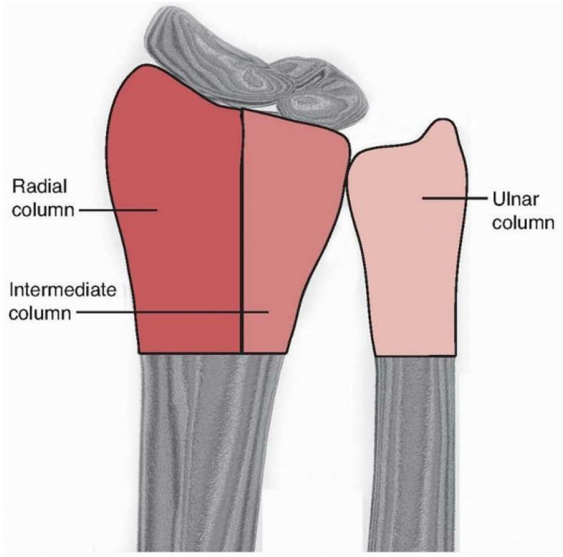
The metaphysis flares distally in both the anteroposterior and the lateral planes with a dorsally and radially lying thinner cortical bone. The thin cortices are clinically significant because the fractures typically tend to collapse in the dorsoradial direction.

The palmar ulnar cortex is richly embedded bone with the greatest trabecular density. The success of internal fixation techniques thrives on the fact that this superior quality thick bone, found in even the osteoporotic cadaver specimens. Distally, the radius attains a roughly trapezoidal shape. The radial styloid rotates palmarly 15 degrees off the axis of the radius. This makes it difficult to keep in reduced position from a dorsal approach. The lunate facet of the radius harbours the strongest bone. The line of force passes down the long finger axis, traversing through the capitolunate articulation, and contacts the radius at the lunate facet[48]. The palmar ulnar corner is the referred-keystone of the radius. It serves as the attachment for the stout radiolunate ligament and palmar distal radioulnar ligaments.



MEASUREMENT OF NORMAL AVERAGE RADIAL ANGULATION (23 DEGREE), RADIAL LENGTH (12MM) AND PALMAR ANGULATION (11 DEGREE)

The three column concept of the wrist was proposed by Rikkli et al. It suggested that each column is subjected to different forces and must be addressed as discrete elements[49].



THREE COLUMNS OF THE DISTAL RADIUS AND ULNA

The radial column consists of the radial styloid and scaphoid fossa. Due to the radial inclination of 22 degrees, shear moment on the radial styloid is caused by impaction of the scaphoid on the articular surface; resulting in a causing failure laterally at the radial cortex. Thence radial column is best stabilized by buttressing the lateral cortex.

The intermediate column compromises of the sigmoid notch and the lunate fossa of the radius. The intermediate column is the keystone of the radius in maintaining the articular congruity and the function of the distal radioulnar joint. The impaction of the lunate on the articular surface with dorsal comminution results in failure of the intermediate column . A direct buttressing on the medial aspect of the radius stabilizes the column.

The ulnar column consists of the ulna styloid, but also compromises the minor relevant TFCC and the ulnocarpal ligaments. More than half of the significant forces of are transmitted across the ulnar column, especially while performing important hand movements like making a tight fist[50].

Ligamentous anatomy:

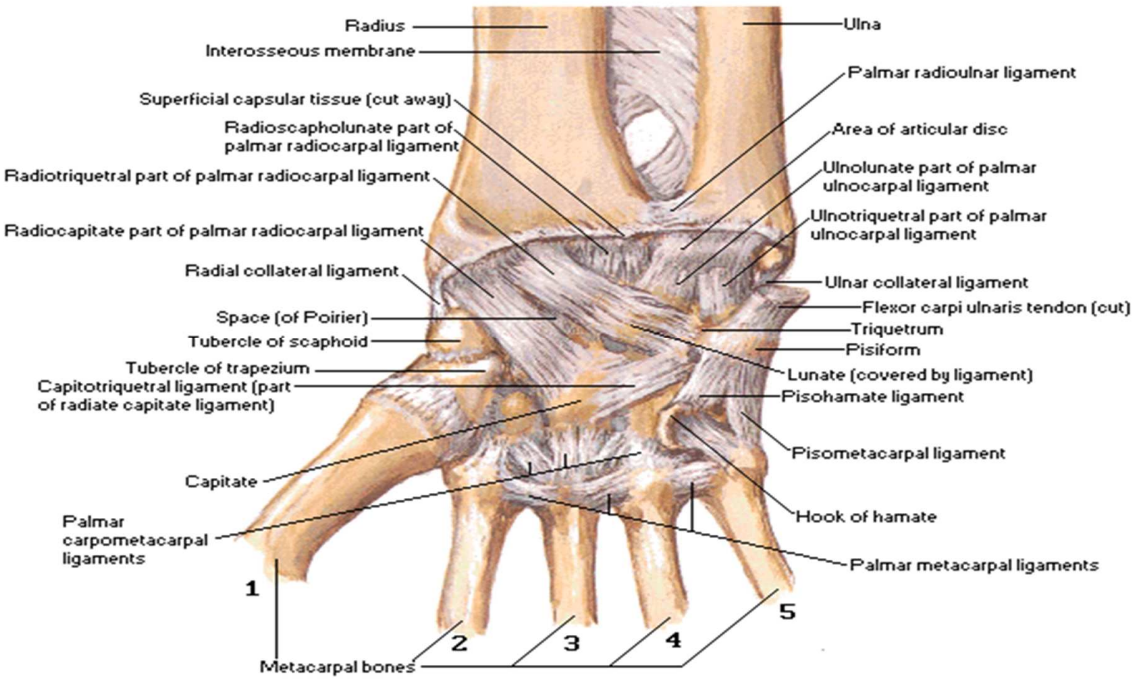
The extrinsic ligaments of the wrist play a major role in the use of indirect reduction techniques. The palmar extrinsic ligaments are attached to the distal radius, and these ligaments are relied on to reduce the components of a fracture using closed methods. There are two factors about these ligaments that make them significant for reduction. First, the orientation of the extrinsic ligaments from the radial styloid is oblique relative to the more vertical orientation of the ligaments attached to the lunate facet.

The second significance of the ligamentous anatomy is due to the relativestrengths of the thicker palmar ligaments when compared with the thinnerdorsal ligaments. In addition, the dorsal ligaments are aligned in Z manner, which makes them lengthen at lesser force than the palmar ligaments. Thesignificance is that distraction will result in the palmar ligaments becomingtaut before the dorsal ligaments. Thus, the palmar cortex is brought out to length before the dorsal cortex. It is for this reason that it is difficult toachieve reduction of the normal 12 degrees of palmar tilt using distractionalone(51).

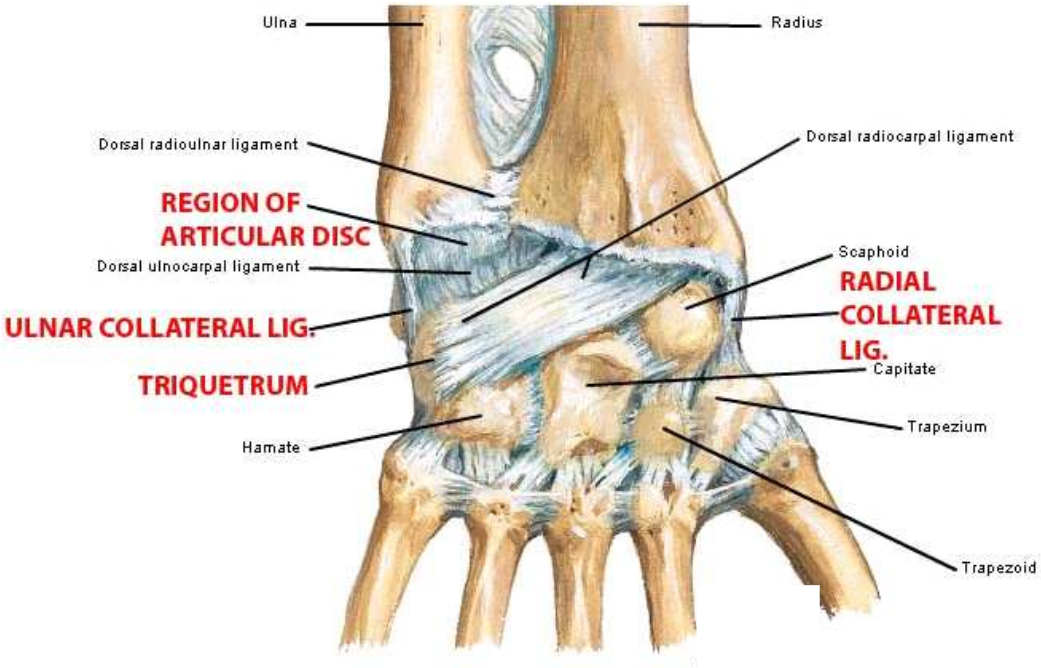
The ulnotriquetral, ulnocapitate and ulnolunate ligaments also are consideredpart of the TFCC. They share a common origin from the region of the ulnar styloid base and fan out past the triangular fibrocartilage to insert on the triquetrum, capitate and lunate respectively. The ligaments are importantstabilizers of the ulnar corner of the wrist and resist palmar and ulnardisplacement of the carpus, particularly in power grip(53).

LIGAMENTS OF THE WRIST

ANTERIOR (PALMAR) VIEW(flexor retinaculum removed)

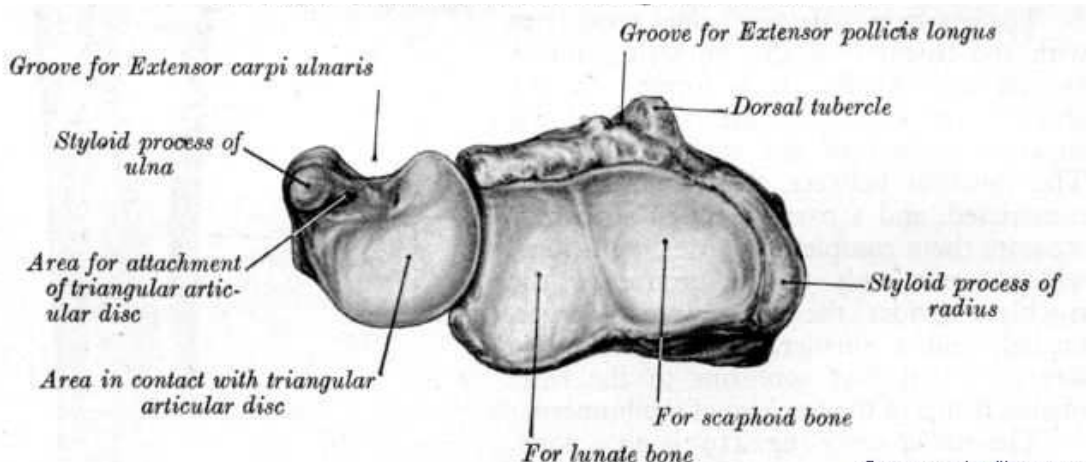


POSTERIOR (DORSAL) VIEW

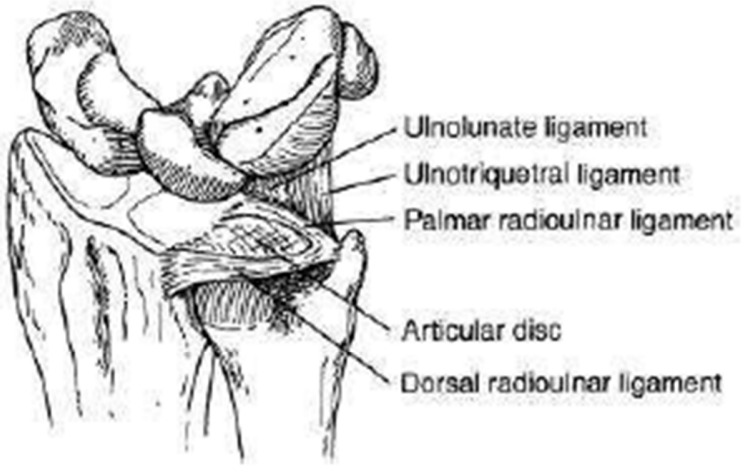


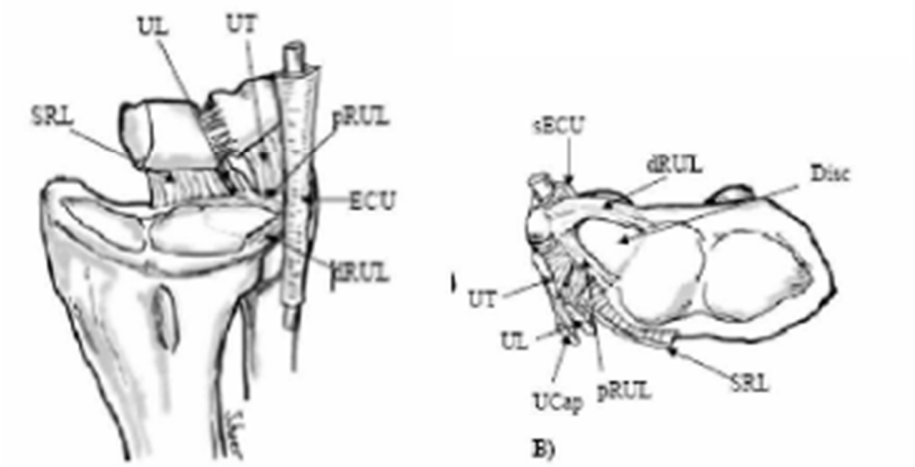
One of the most important structures is the triangular fibrocartilage complex (TFCC), a term coined by Palmer and Werner. It arises from the ulnar aspect of the lunate fossa of the radius and courses ulnarward to insert into the base of the ulnar styloid. It also flows distally, where it is joined by fibers arising from the ulnar aspect of the ulnar styloid and inserts distally into the triquetrum, hamate, and base of the fifth metacarpal. In the center of the complex is the triangular fibrocartilage (TFC) proper. The periphery of the TFC is thickest, usually measuring 5 mm, and is the portion best suited to bear tensile loads. The rim is well vascularized and therefore has good healing potential.

DISTAL ARTICULAR SURFACE OF RADIUS AND ULNA SHOWING TRIANGULAR FIBRO CARTILAGE ATTACHMENT



TRIANGULAR FIBRO CARTILAGE COMPLEX AND ITS COMPONENTS





UL- Ulnolunate ligament

UT- Ulnotriquetral ligament

pRUL&dRUL – Radioulnar ligament

Uncap – Ulnocapitate ligament

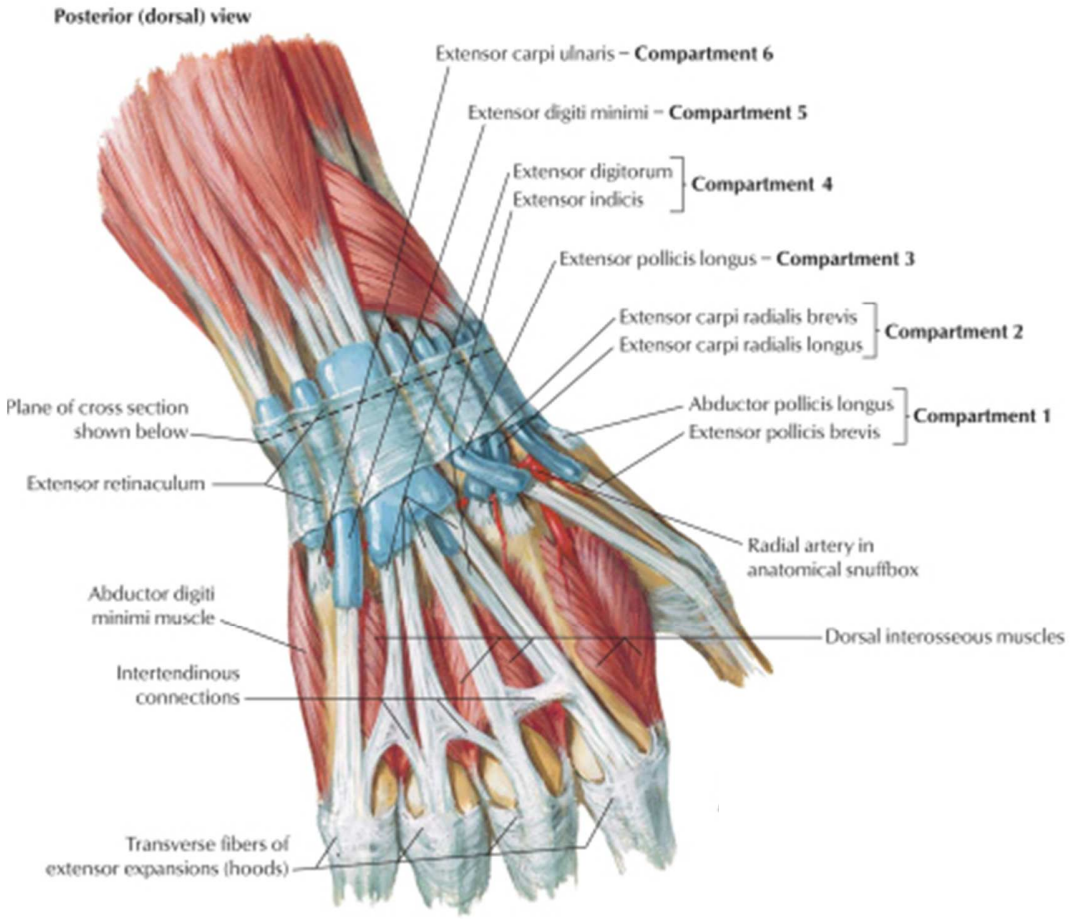
ECU- Extensor carpi ulnaris

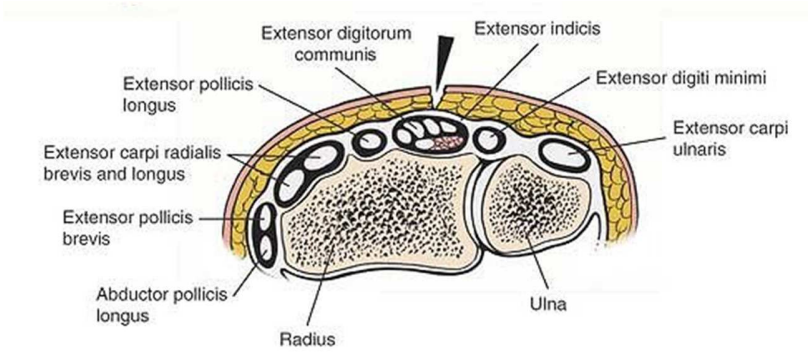
Muscular anatomy

The muscles of importance in the distal end of radius are pronator quadratus and extensor carpi ulnaris which are the two dynamic stabilizers of the distalulna. The pronator quadratus has a superficial head, which is a prime moverfor forearm pronation, and a deep head, which helps stabilize the DRUJ. The pronator quadratus actively stabilizes the joint, by coaptation the ulnar head inthe sigmoid notch, particularly in pronation, and passively stabilizes the jointby viscoelastic forces in supination.

The ECU musculotendinous unit has unique features that lend additionalstability to the DRUJ complex. Spinner and Kaplan (54)and Taleisnik et al demonstrated how the ECU is maintained in its position over the dorsal distal ulna by a separate fibroosseous tunnel deep to and separate from the extensor retinaculum and its significance in distal radioulnar stability by the bowstring effect. Brachioradialis is inserted into the radial styloid raising concern in comminuted fractures where radial styloid is seen as a separatefragment.

The extensor retinaculum is a narrow (2-cm) fibrous band that lies obliquely across the dorsal aspect of the wrist. It is attached radially to the anterolateral border of the radius; on its ulnar aspect to the pisiform and triquetral bones.





DISTAL WRIST JOINT & DORSAL APPROACH TO DISTAL RADIUS AND ULNA

Fibrous septa pass from the deep surface of the extensor retinaculum to the carpals, dividing the extensor tunnel into 6 compartments. From the lateral to medial aspect, the compartments contain the following:

- Abductor pollicis longus(APL) and Extensor pollicis brevis(EPB). They lie over the lateral aspect of the radius and often become trapped or inflamed beneath the extensor retinaculum in their fibroosseous canal. This forms the pathology in de Quervain's disease.

- Extensor carpi radialis longus(ECRL) and extensor carpi radialis brevis (ECRB).

  Both ECRL and ECRB run on the radial side of Lister's tubercle in separate synovial sheaths. The ECRL tendon is used in tendon transfers frequently.

- Extensor pollicis longus(EPL).

  EPLruns on the ulnar side of Lister's tubercle, before passing into the dorsum of the hand. Since it passes obliquely into the dorsum of wrist,

dorsal plating of distal radius fractures becomes cumbersome. It may be ruptured in association with fractures or rheumatoid arthritis.

- Extensor digitorum communis(EDC) and extensor indicis (EI).

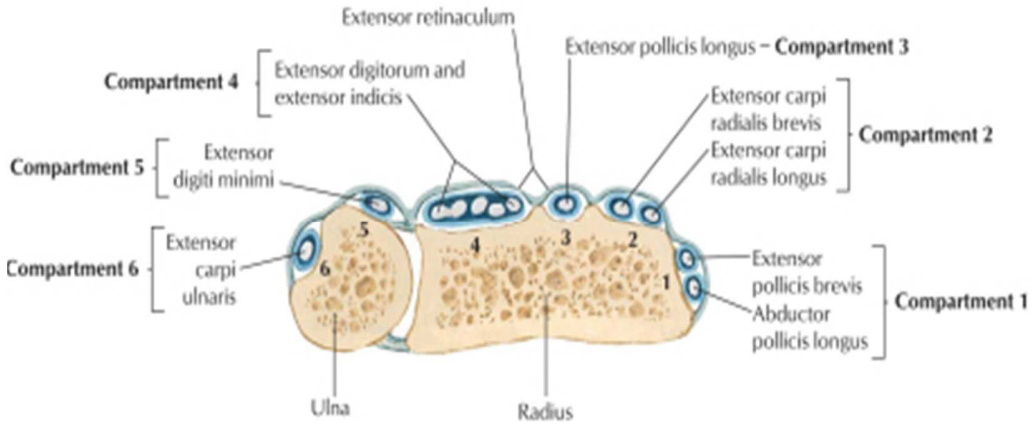
  EI tendon is used commonly in tendon transfers.

- Extensor digiti minimi (EDM)

  EDM overlies the distal radioulnar joint.

- Extensor carpi ulnaris(ECU).

  ECU passes near the base of the ulnar styloid process.

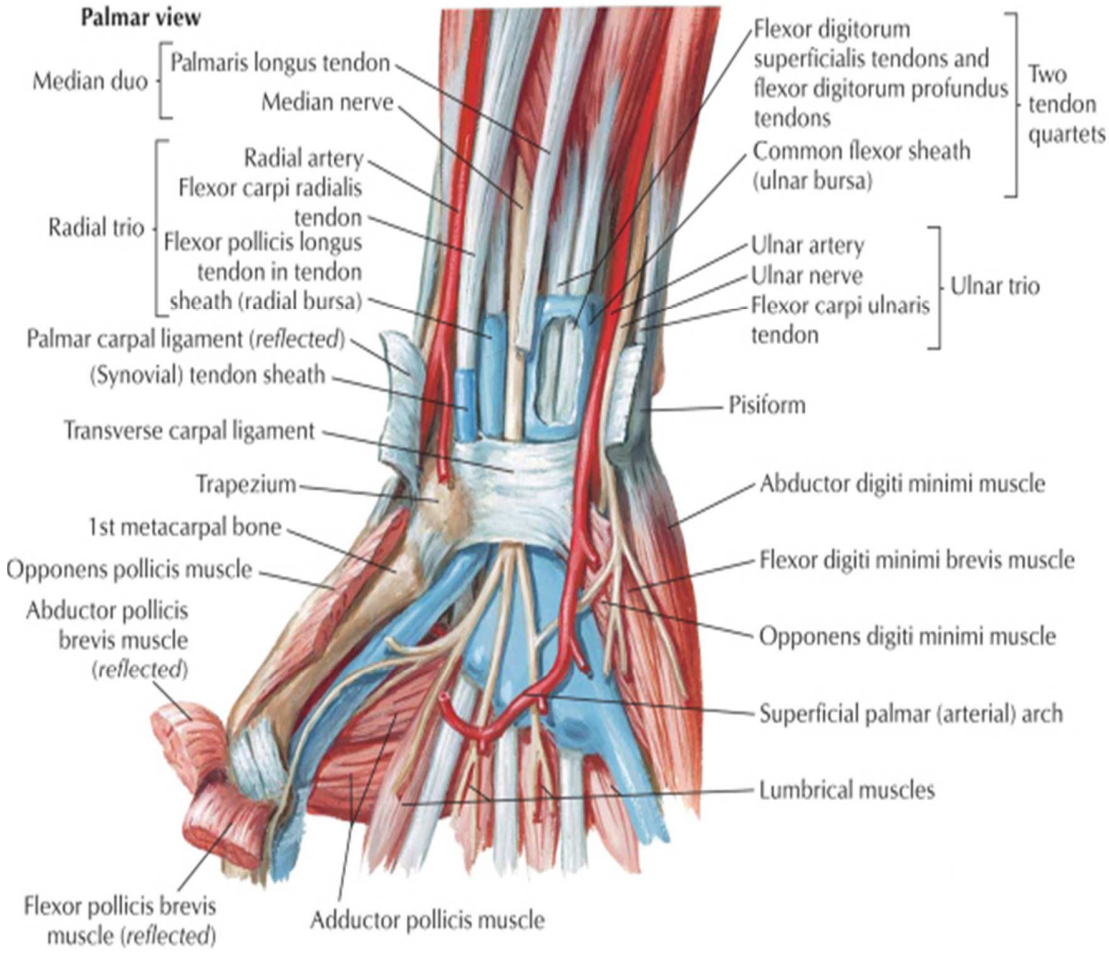


CROSS SECTION OF DISTAL FOREARM

The flexor tendons related to the anterior aspect of the distal radius are flexor carpi radialis, Palmaris longus, individual tendons of flexor digitorum superficialis and profundus.

- Tendon of the palmaris longus.

  It is a vestigial muscle, used frequently for tendon grafting and as an anatomic landmark for the injection of steroid into the carpal tunnel.It is absent in about 10% of the population. It is easily palpable together with the thicker and more radially located tendon of the flexor carpi radialis when wrist is flexed the wrist against resistance.



VOLAR ASPECT OF WRIST JOINT

- Flexor Digitorum Superficialis (FDS)

  The tendons to the middle and ring fingers are superficial to the tendons of the index and little fingers within the carpal tunnel.

- Flexor Digitorum Profundus (FDP)

  FDP tendons lie deep to the tendons of the FDS.

- Flexor Pollicis Longus (FPL)

  FPL tendon lies deep to that of the FCR and is found on the most radial aspect of the canal at the same depth as FDP tendons.

- Flexor Carpi Radialis (FCR)

  FCR perforates the flexor retinaculum to lies in the groove of the trapezium after perforating the flexor retinaculum. It insertion is in the bases of the second and third metacarpals and does not pass through the carpal tunnel.

Neurovascular anatomy:

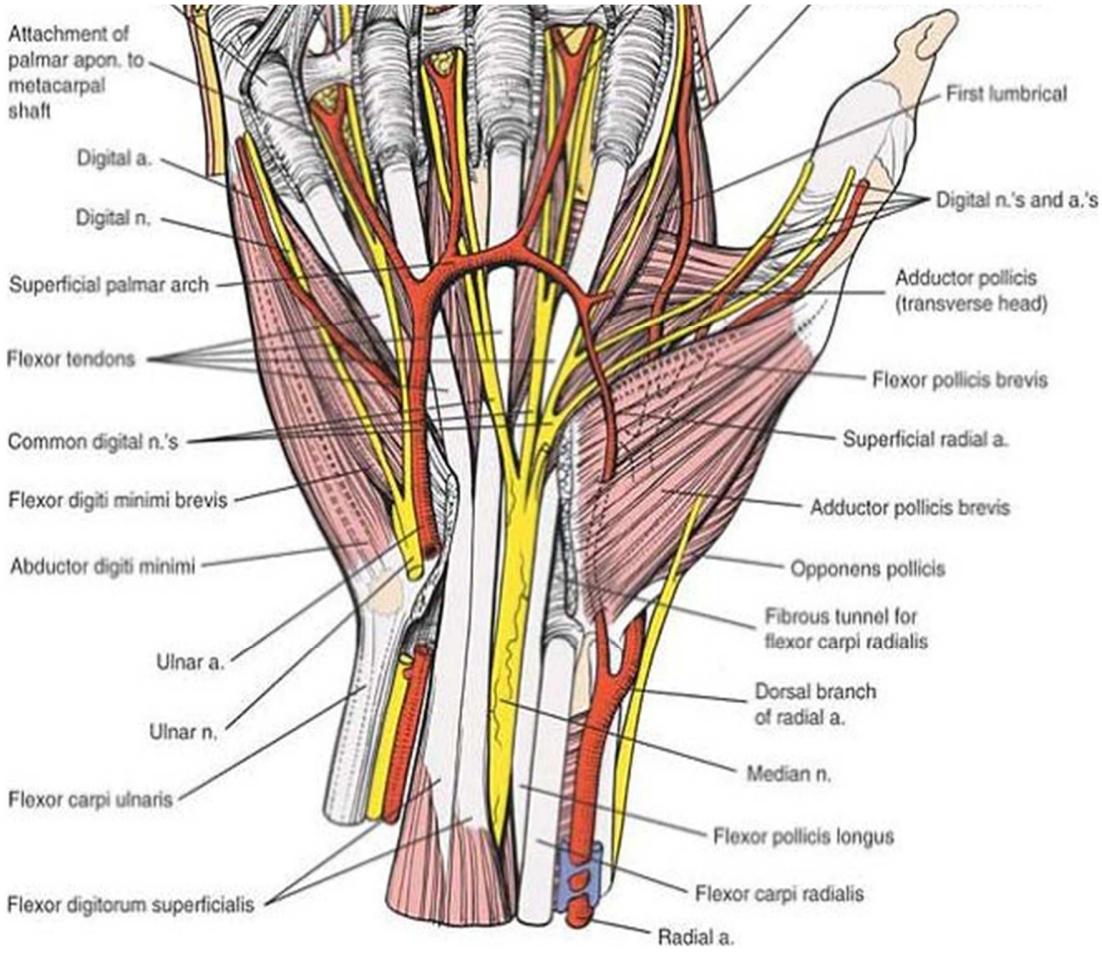
The radial artery lies anterior to the pronator quadratus muscle and the distalend of the radius lateral to the flexor carpi radialis muscle. It leavesthe forearm by winding lateral to radial styloid. The radial pulse can be felt by gentlypalpating the radial artery against the underlying muscle and bone.

The ulnar artery often remains tucked under the anterolateral lip of the flexor carpi ulnaris tendon and enters the hand by passing lateral to the pisiformbone and superficial to the flexor retinaculum of the wrist, and arches overthe palm.

The median nerve becomes more superficial in position at the level of thedistal radius, lying between the tendons of the palmaris longus and flexor carpi radialis muscles. It leaves the forearm and enters the palm of the hand by passing through the carpal tunnel deep to the flexor retinaculum.

The ulnar nerve lies lateral to flexor carpi ulnaris nerve and enters the hand, by passing superficial to the flexor retinaculum, medial to ulnar artery and immediately lateral to the pisiform bone.

The superficial branch of the radial nerve lies on the lateral aspect of thewrist in close association with the brachioradialis tendon.



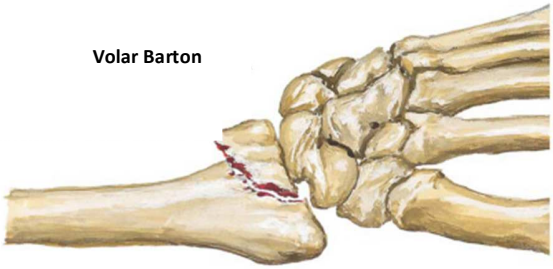
VOLAR ASPECT OF WRIST BEFORE AND AFTER ELEVATING PALMAR APONEUROSIS SHOWING FLEXOR TENDONS, DIGITAL NERVES AND SUPERFICIAL PALMAR ARCH

MECHANISM OF INJURY

Distal radius fractures usually occur after a fall on an outstretched hand withwrist in dorsiflexion. The type is determined by the rate, magnitude and thedirection of the load. The position of the hand at the time of the injury andthe bone quality also determines the fracture pattern to some extent.

Colles fracture

Die-punch, comminuted
Colles fracture



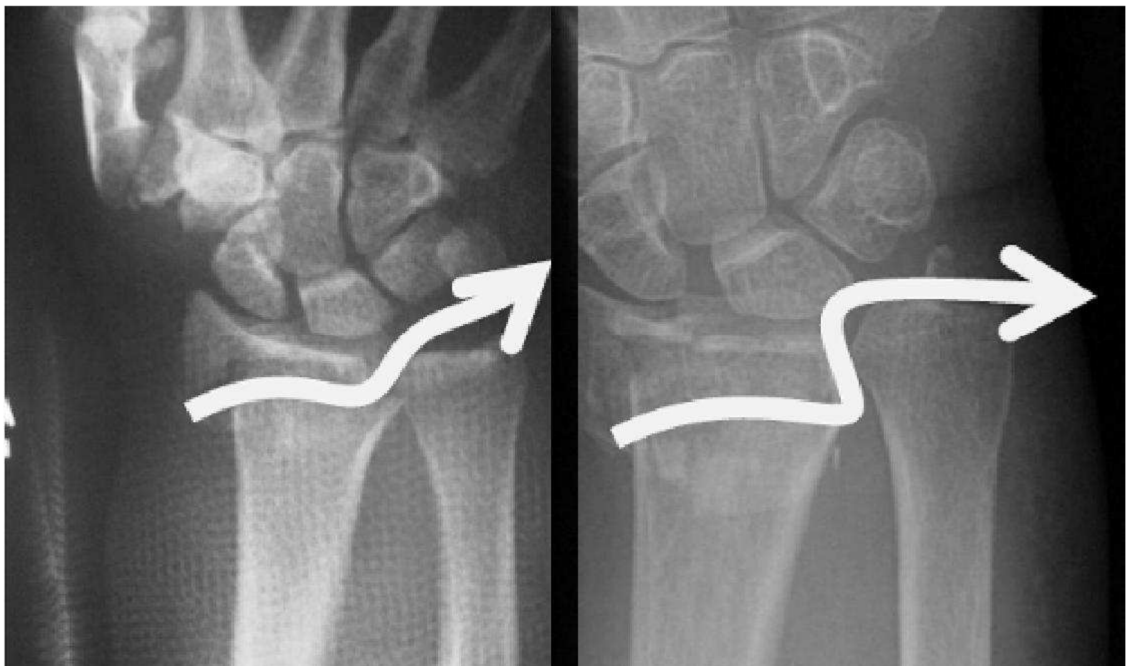
Volar Barton

Shearing forces over the distal radius by the carpal bones at an inclinedangle during the fall leads to partial articular fractures. Volar and dorsalBarton fracturesare due to such shear forces exerted by the lunate over thedistal radius during fall on outstretched hand. Radial styloid fracture occurs by the scaphoid eccentrically loading on the radial column of the distalradius[55].

Avulsion typesof fractures occur by the indirect transmission of the tensileforces exerted over the bone by the ligaments41. Volar radio carpal ligamentsor the radial collateral ligament do avulse the bony fragments as the forcedictates.

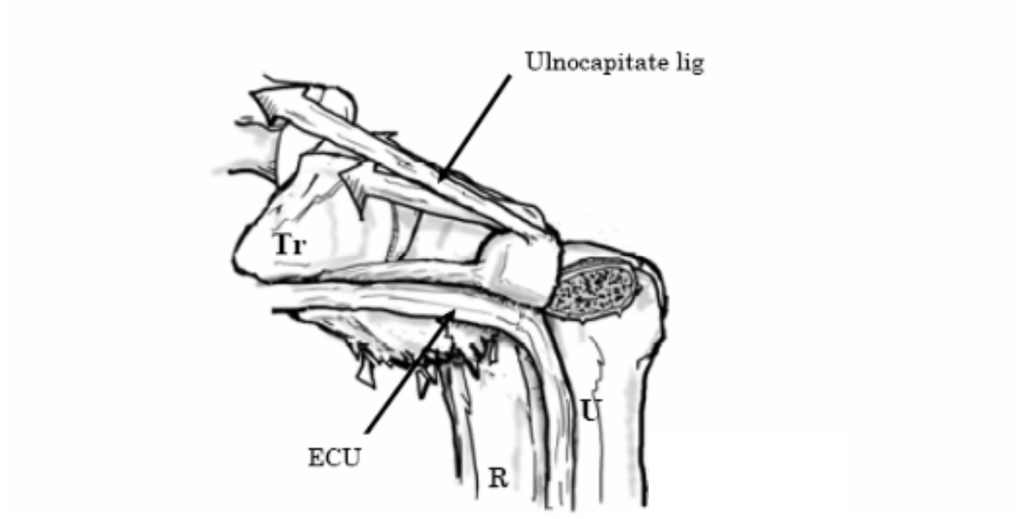
A fall on the outstretched hand with the wrist joint in 40° to 90° of extensionproduces a dorsally displaced distal radius fracture[11,17]. The radius probablyfractures first in tension on its palmar surface, followed by compression onthe dorsal surface, resulting in dorsal comminution. This is explained by the bending or incurvation theory. Loading at 70 to 90 degrees of dorsiflexion resultsin highly comminuted distal radius fractures, while those at lower angles(20 to 40 degrees) of extension results in minimal comminution. Dorsiflexion, when it ismore than 90degrees at the time of impact, results in carpal injuries[56].

DRUJ mechanisms:



TFCC tear Basi-styloid fracture

The progressive dorsal angulation and displacement but with lessmagnitude leads to extensor carpi ulnaris sheath rupture followed by ulnar styloid tip fracture due to ulnotriquetral ligament avulsion. With greater magnitude of force the palmar ulnocarpal ligaments namely ulnotriquetral, ulnolunate and ulnocapitate ligaments pull forcefully exceeding the bowstringing of ECU leading to basal fracture of ulnar styloid process starting from the palmar side(57).

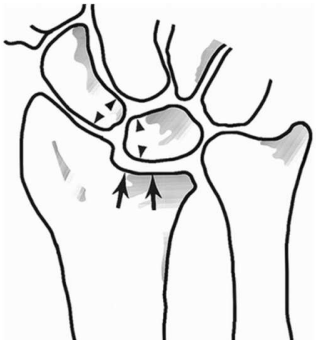


Base of ulnar styloid process fracture

Compression forces are predominant in high-energy, axial loading injuries and lead to impaction of articular fragments(55). These types of fractures are usually associated with interosseous membrane rupture in case of pure axial force and base of ulnar styloid fracture if dorsal angulation force is associated.

Die Punch fracture

Depressed fracture of the lunate fossa involving the articular surface of the distal radius



CLASSIFICATION:

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

Frykman first described distal ulna fractures associated with distal radius fractures. He established an eponymous classification system[17], which defines the fracture as intra-articular or extra-articular. It also describes the involvement of radiocarpal and distal radioulnar joints along with the presence or absence of ulnar styloid process fracture. This system does not quantitatively assess the degree of comminution, shortening and the initial impact. Hence, the prognostic value is low in suggesting a treatment..

Type I: Extra-articular fracture

Type II: Extra-articular fracture with ulnar styloid fracture

Type III: Radiocarpal articular involvement

Type IV: Radiocarpal involvement with ulnar styloid fracture

Type V: Radioulnar involvement

Type VI: Radioulnar involvement with ulnar styloid fracture

Type VII: Radioulnar and radiocarpal involvement

Type VIII: Radioulnar and radiocarpal involvement with ulnar styloid fracture

Fernandez proposed a mechanism-based classification system that would address the potential for ligamentous injury and thereby assist in treatment recommendations.

Type I: Metaphyseal bending fractures with the inherent problems of loss of palmar tilt and radial shortening relative to the ulna (DRUJ injuries).
Type II: Shearing fractures requiring reduction and often buttressing of the articular segment.
Type III: Compression of the articular surface without the characteristic Fragmentation. It also includes the potential for significant interosseous ligament injury.
Type IV: Avulsion fractures or radiocarpal fracture dislocations.
Type V: Combined injuries with significant soft tissue involvement due to the high-energy nature of these fractures.

Gartland and Werley proposed a classification system that assessed the three basic components of these injuries: (1) metaphyseal comminution, (2) intra-articular extension, and (3) displacement of the fragments

Group I: Simple Colles' fracture with no involvement of the radial articular surfaces

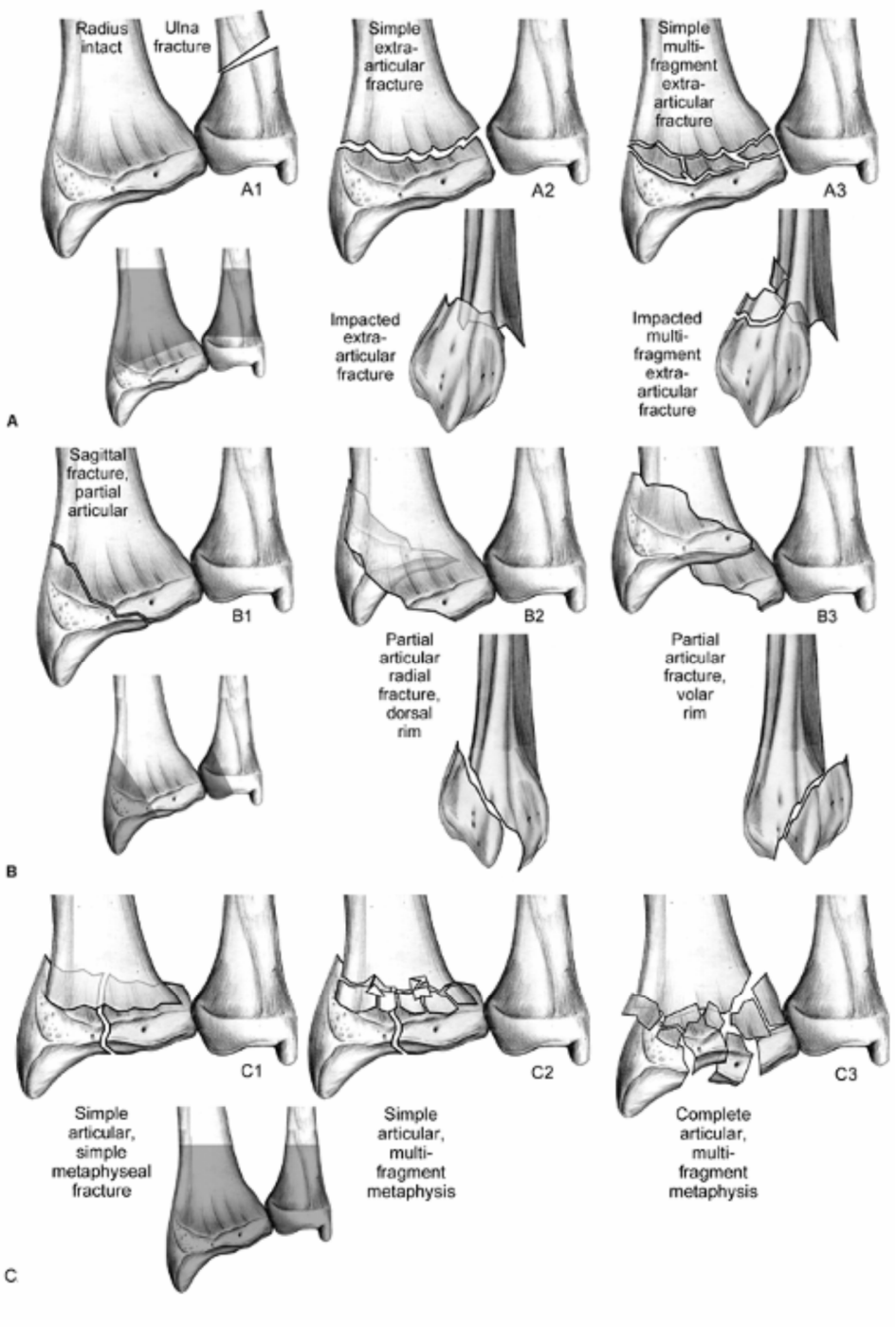
Group II: Comminuted Colles' fractures with intra-articular extension without displacement

Group III: Comminuted Colles' fractures with intra-articular extension with displacement

Group IV: Extra-articular, undisplaced

Muller AO developed the Comprehensive Classification for Long Bone Fractures. The distal radius and ulna are designated as 23 and is further classified into three types as given below.

We followed the AO classification in our study


Radius intact
Ulna fracture
A1
Simple extra-articular fracture
A2
Simple multi-fragment extra-articular fracture
A3
Impacted extra-articular fracture
Impacted multi-fragment extra-articular fracture
A
Sagittal fracture, partial articular
B1
B2
Partial articular radial fracture, dorsal rim
B3
Partial articular fracture, volar rim
B
C1
C2
C3
Simple articular, simple metaphyseal fracture
Simple articular, multi-fragment metaphysis
Complete articular, multi-fragment metaphysis
C

Modified AO Classification was developed and is simplified to 5 patterns

A – Extra-articular

B – Partial articular ; B1 : Radial Styloid

B2 : Dorsal rim fractures

B3 : Volar rim fractures

B4 : Die Punch fractures

C – Completearticular

The only modification to the AO system was the addition of the "die-punch"fracture to the partial articular fractures group.

RADIOLOGICAL EVALUATION:

The radiological assessment of the post-operative fixation of the fractures was done using Xrays and CT scans.

Standard anteroposterior and lateral views were taken to assess fracturepattern and to assess the parameters like palmar tilt, radial height, radialinclination, displacement and involvement of radiocarpal and distal radio-ulnar joints.

1. Radial angulation or inclination – angle between the distal radial articular surface to a line drawn at right angles axis of the radial shaft. Average is about 23 degrees (range 15 to 25 degrees).

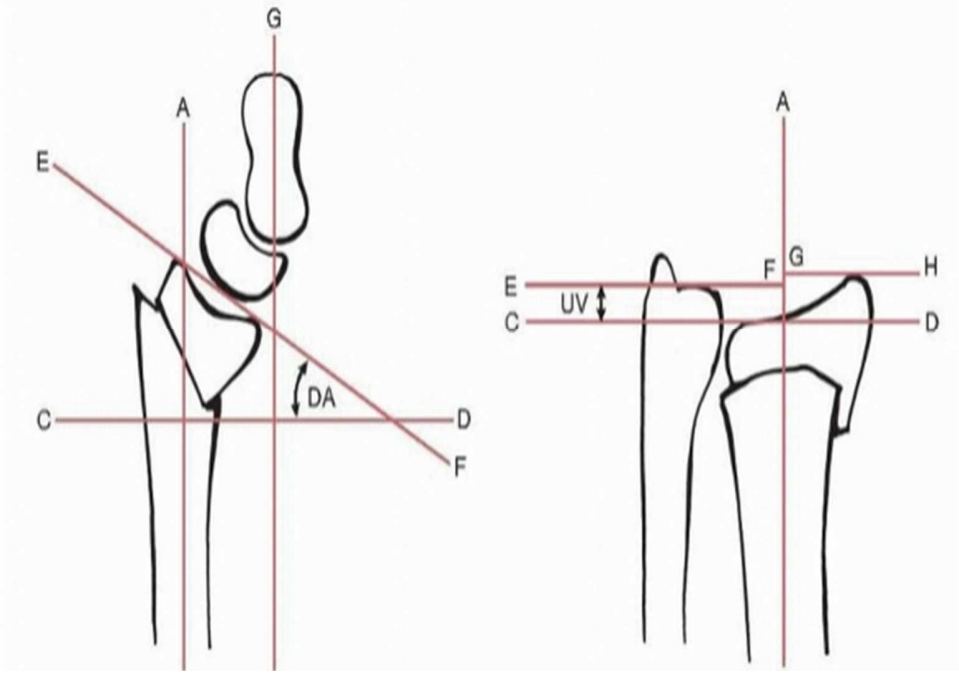
2. **Radial length –** distance between two perpendicular lines to the long axis of the radius, one at the tip of the radial styloid process and the other at the surface of ulnar head. Average is 11 mm (8 to 18 mm).

3. **Ulnar variance –** is the vertical distance between the distal ends of the medial corner of the radius and the lateral corner of the ulnar head.

4. **Radial Shift (Width) –** is the amount of displacement of the distal fragment. It is measured between the longitudinal axis of the centre of radius and the lateral point of the radial styloid.

5. **Palmar tilt** – is the relative angle of the distal radial articular surface in

relation to the radial shaft in coronal plane. This averages about 11 degrees.

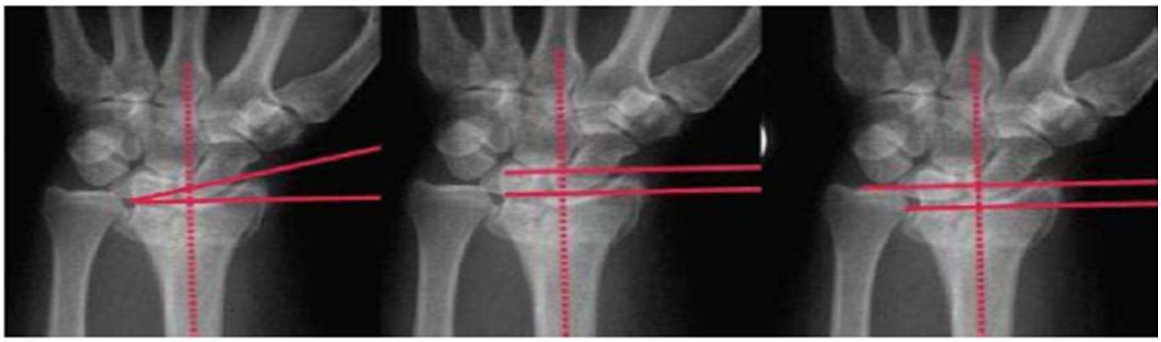


Dorsal angle is the angle between CD (line perpendicular to radius long axis) and EF (line joining the dorsal and volar extremities of radiocarpal joint

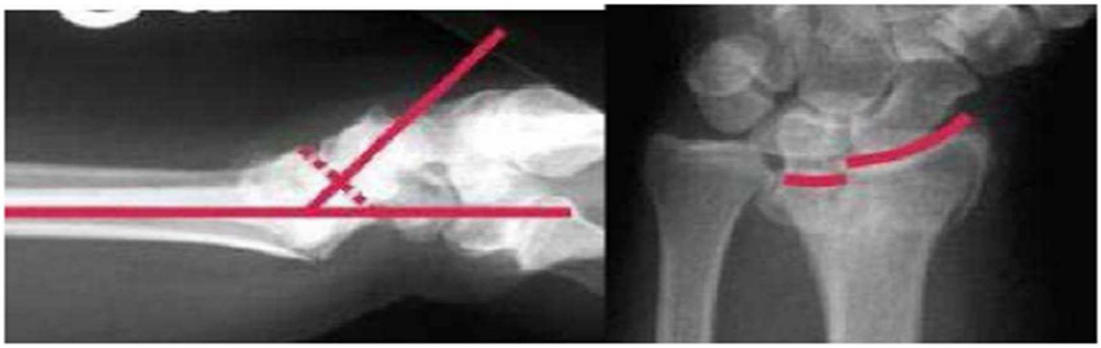
Carpal alignment is assessed by the point of intersection of AB (line parallel to radius long axis) and GH (line parallel to long axis of capitate). If they interact outside the carpus or don't interact, then the carpus is malaligned.

Ulnar variance(UV) is the distance between two lines perpendicular to AB (long axis of radius) i.e. CD (at ulnar corner of radius) and EF (tangential at ulnar head)

Radial Length is the distance between lines EF and GH (line tangential to the radial styloid).



Radial inclination **Radial height** **Ulnar variance**



Palmar tilt **(Dorsal tilt illustrated) Articular step**

Standard and tilted lateral views

The tilted lateral viewwas also taken, which is a lateral view taken with a pad under the hand to incline the radius 22 degrees toward the beam. It eliminatesthe shadow of the radial styloid and provides a clear tangential view of thelunate facet in assessing the depression of the palmar lunate facet.

Oblique views with the wrist in 45 degrees of supination and pronation help invisualizing the fracture lines more clearly.X rays taken with the wrist in manual traction are the most accurate indescribing the fracture pattern. Traction restores the gross anatomy of thelimb and reduces overlap.

Computed Tomography:

CT scans have joined the armamentorium of investigations in distal radius fractures. They provide the best assessment of articular surface depression, comminution and displacement. In few numbers of cases with suspicion of severe comminution and displacement, CT of Wrist with 3D reconstruction was done for pre-operative planning.

APPROACHES OF DISTAL RADIUS

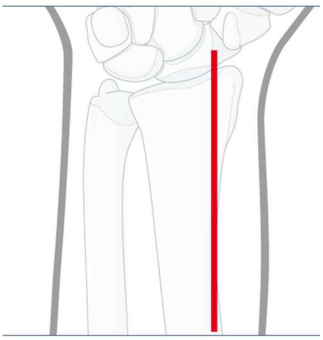
There are predominantly 2 approaches of distal radius fixation

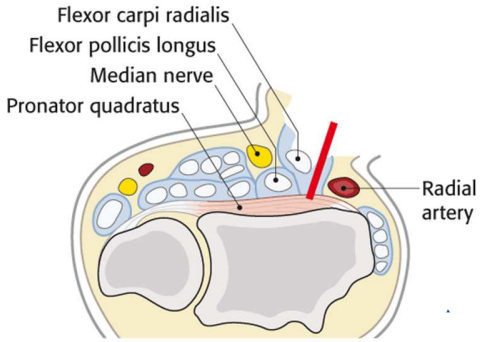
VOLAR APPROACH

2 surgical approaches to the distal radius through the palmar aspect have been described

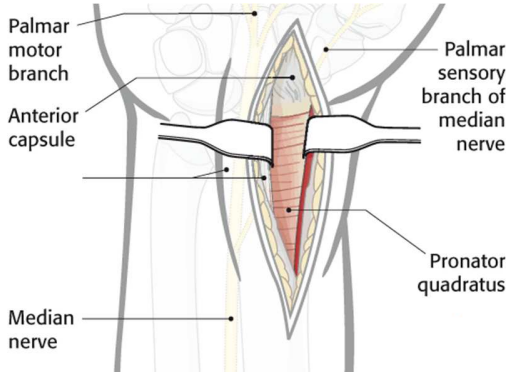
a) Modified Henry approach to the radius

   It is suitable for most distal radial fractures.This approach utilizes the plane between flexor carpi radialis(FCR) tendon and the radial artery, i.e. , ulnar to the radial artery. The classical Henry approach uses the plane between brachioradialis and the radial artery, i.e. , radial to the radial artery. During modified Henry approach, radial artery and the palmar branch of the median nerve are at risk of injury. The salient features are as below

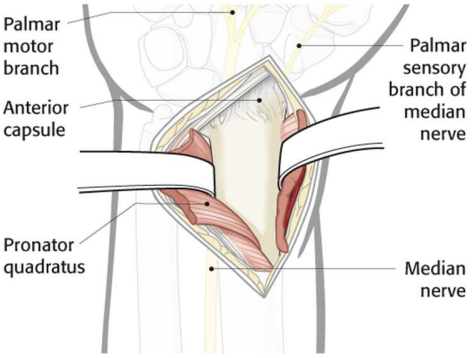




Plane of approach in cross section between FCR and radial artery



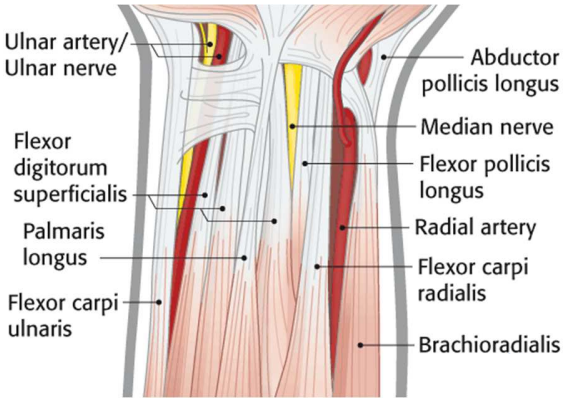
FCR is retracted ulnarly while radial artery is retracted radially



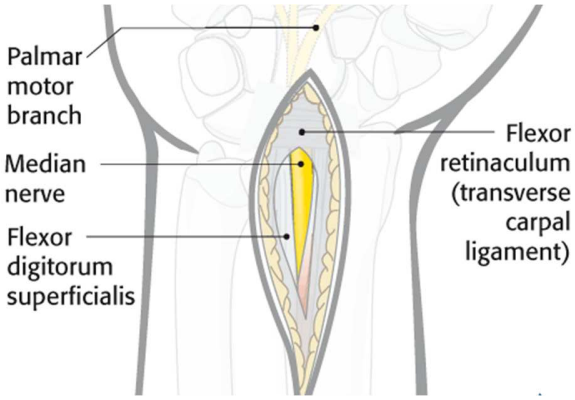
Exposure to distal radius is completed by erasing the pronator quadratus off

b) Extended carpal tunnel approach,

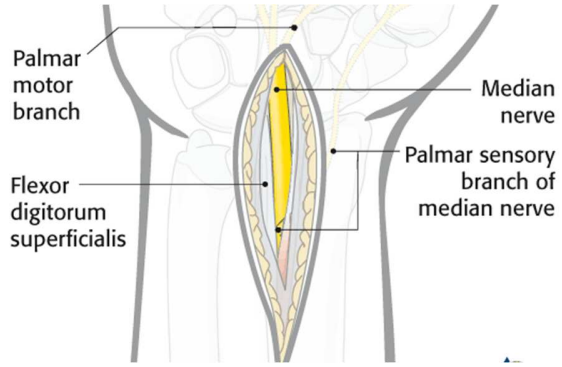
It is a more ulnar technique designed to expose the median nerve as well as the distal radius.It is mainly used in the carpal tunnel decompression and exposure of the distal radioulnar joint the sigmoid notch and distal ulna in addition to the distal radius exposure. The median nerve is the structure at most risk and mobilization of the nerve requires formal division of the flexor retinaculum (transverse carpal ligament), opening the carpal tunnel. It is less suitable for the radial part of the distal radius



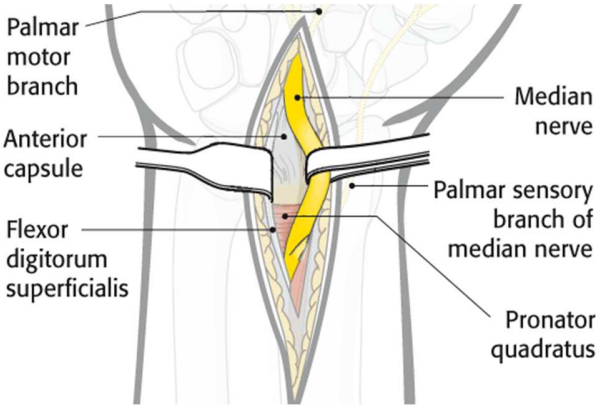
This approach uses plane between palmaris longus and FDS medially and FCR laterally.



Superficial surgical dissection involves division of the deep fascia and medial retraction of the palmaris longus muscle



Division of the flexor retinaculum allows decompression of the median nerve.

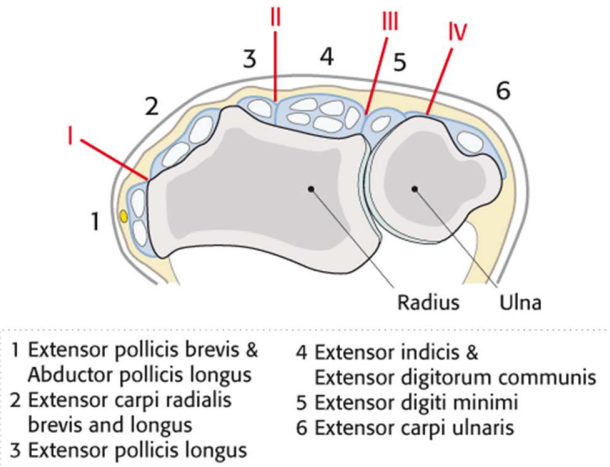


Retraction of the median nerve reveals the capsular structures and the pronator quadratus muscle, which needs to erased for visualizing distal radius.

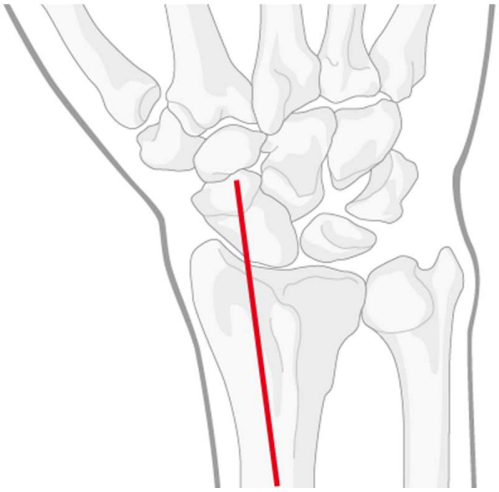
DORSAL APPROACH

Dorsal approaches can be done between the different extensor compartments (I-IV) but through the third extensor compartment (II), it allows better approach to intermediate and the radial columns. The skin incision is centered over the Listers tubercle. The EPL tendon is free while the 4thcompartment is subperiosteally elevated to expose the intermediate column. The radial column is exposed by going in plane between 1st and

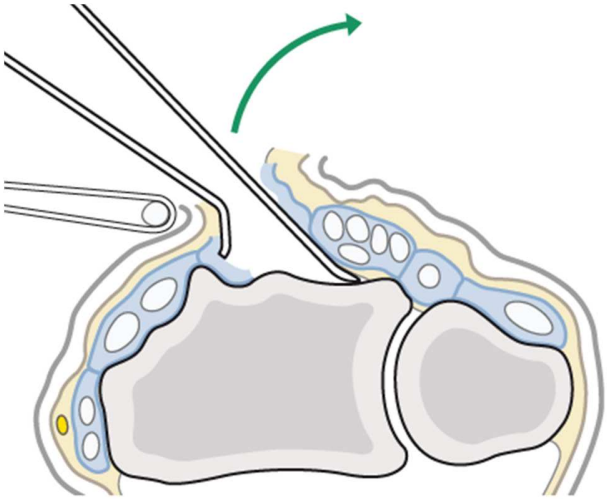
2nd compartment. The 2nd compartment must not be opened and skin flap must be handled with care to prevent injury to the superficial branch of radial nerve. This method is under criticism largely due to the extensor tendon related complications (localirritation and tenosynovitis) and resultant volar collapse.



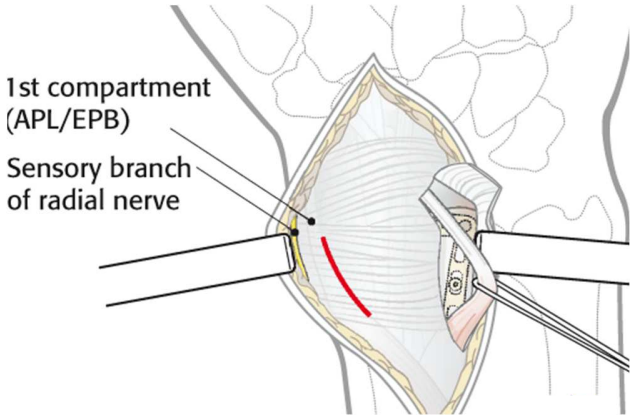
Dorsal approaches can be done between the different extensor compartments can be chosen (I-IV).



Skin incision is centered over the Lister's tubercle



Approach to Intermediate column after mobilizing EPL and elevating 4th compartment



Approach to Radial column between 1st and 2nd compartment

MODALITIES OF DISTAL RADIUS FIXATION

The various internal fixation options in the fixation of distal radius are dorsal or volar T-buttress plate, side-specific Ellis plate, 3.5 mm locking compression plate, 2.4 mm Locking compression plate, cannulated screws, external fixator and Kirschner wires.

Volar LCP Fixation

The Volar LCP aids in perfect stabilization of anatomical reduction of the distal radius fracture. It has several advantages over traditional plating of distal radius

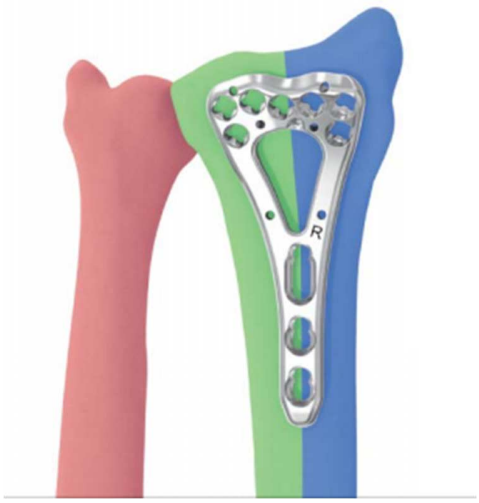
- Fixed- angle constructs are formed by the threaded hole section for locking screws
- Limited-contact (LC) plate design reduces plate-to-bone contact. Therefore there is less vascular trauma.
- Optional placement of conventional screws are provided by smooth dynamic compression unit (DCU) hole section

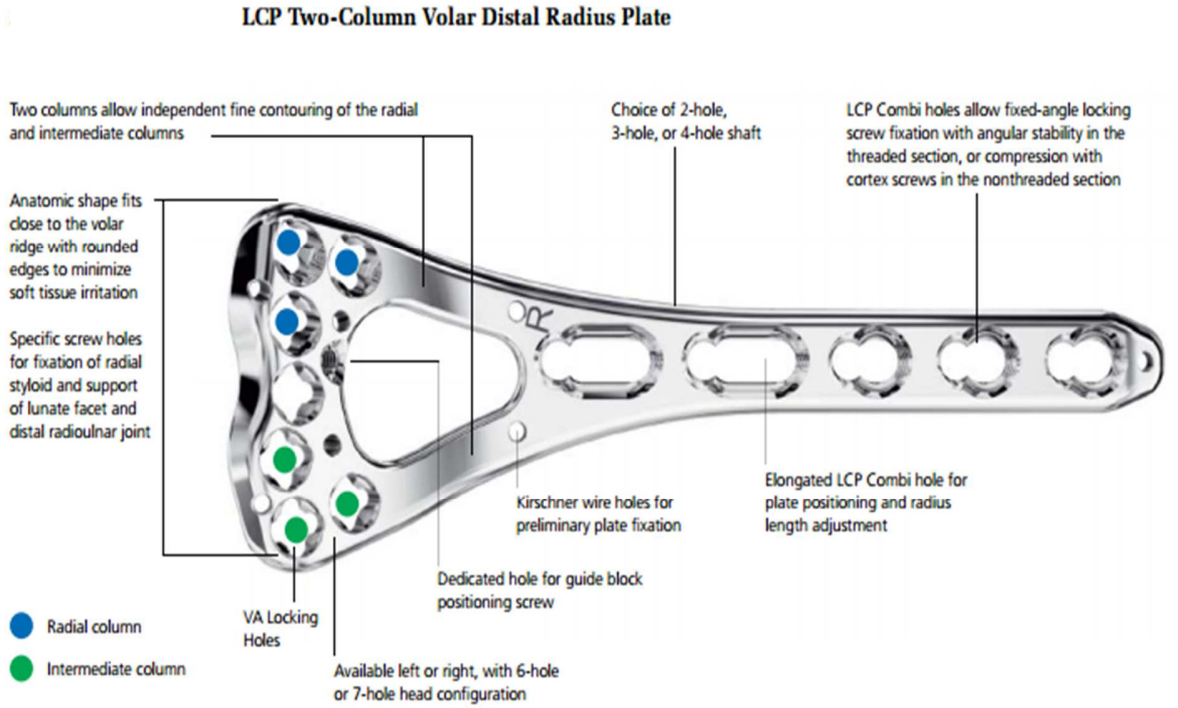
Two-Column Volar distal radius Locking Compression Plate (LCP) was used in our study. It is side-specific.

Its principle advantages over traditional LCP are

- Screws can be angled within a 30° cone around the central axis of the plate hole
- It forms a fixed-angle construct at the desired screw angle by the help of 4 columns of threads in the variable angle locking hole provided by four points of threaded locking between the variable angle LCP plate and the variable angle locking screw
- Two columns of the plate allow visualization of the fracture and independent contouring of the radial and intermediate columns
- Fixation of radial styloid, support of the lunate facet and distal radioulnar joint are addressed by specific screw holes.
- Minimal soft tissue irritation by the anatomic shape and better fit to the volar ridge with rounded edges.

2- Column distal radius Volar LCP allowing fixation and buttressing of both radial(blue) and intermediate (green) columns





DESCRIPTION OF TWO- COLUMN VOLAR DISTAL RADIUS LCP

Bridging External Fixator

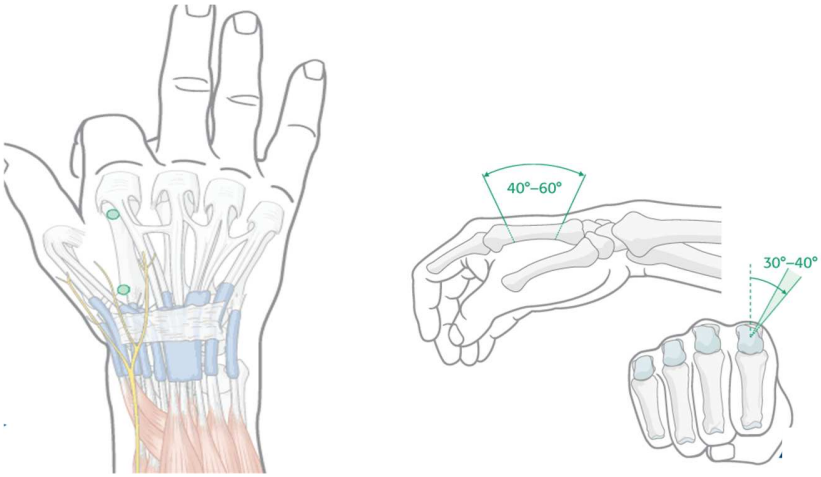
Bridging external fixation of distal radius fractures predominantly bases on the principle of ligamentotaxis to both obtain and maintain a reduction of the fracture fragments. When longitudinal traction is applied to the carpus, the tension is transmitted mostly through the radio-scapho-capitate and long

radiolunate ligaments to restore the radial length. The supination deformity of the distal fragment is corrected indirectly by the pronation of the carpus.

The rigidity of the frame determines the fracture distraction and fixation in the short-term basis. This mainly depends on the diameter of the rod, placement of 2^{nd} parallel rod and placement of 1^{st} rod close to skin. Maintenance of fracture fixation can be augmented by percutaneous pin fixation. This locks the radial styloid buttress and supports the lunate fossa fragment. This prevents a loss of radial length through settling and an improved wrist range of motion compared with a four-pin external fixator alone. Dorsal pin attached to a sidebar easily corrects the dorsal tilt.
Above all, the augmentation of an external fixator with 1.5mm K wires approaches the strength of a 3.5-mm dorsal AO plate, thereby enhancing the reduction and rigidity of the construct.

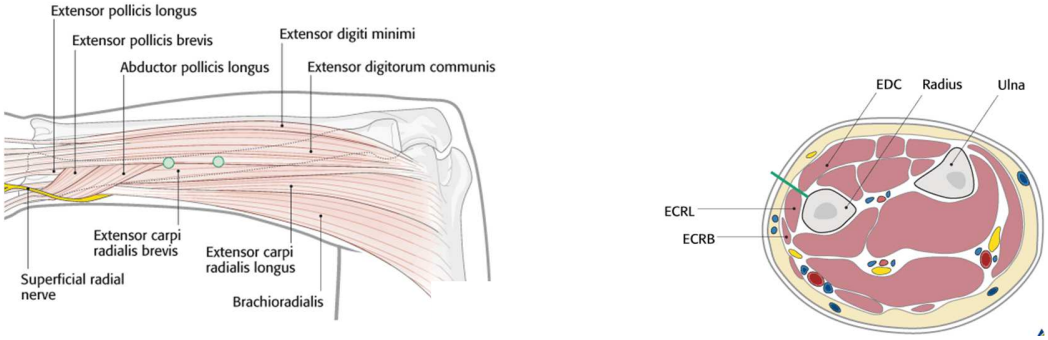
The techniques of external fixator application are
The distal metacarpal pin is inserted 3 mm proximal to the transition of the metacarpal head into the shaft while the proximal pin is inserted 3 mm distal to the transition of the shaft into the metacarpal base. The index metacarpophalangeal joint can be passively flexed 90º so that the extensor

hood moves slightly in an ulnar direction, away from the metacarpal shaft to prevent the transfixing the extensor tendon by the distal screw.

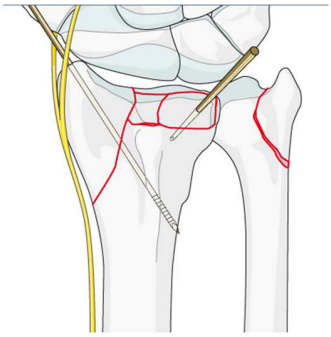


TECHNIQUE OF INSERTION OF METACARPAL PINS

The radial pins are inserted by stab incisions proximal to the muscle bellies of APL and EPB over a distance of 3-4 cm. Blunt dissection down to the bone after preserving nerve branches. 2 Pins should be inserted in the transverse plane at 45° to the frontal plane and 45° to the sagittal plane.



TECHNIQUE OF INSERTION OF RADIAL PINS



K- WIRE AUGMNETATION FOR DISTAL RADIAL ARTICULAR FRAGMENTS

Issues related when applied in the displaced intra-articular fractures of the distal radius mainly is gradual loss of the initial distraction force applied to the fracture site through stress relaxation (as ligaments are viscoelastic). The immediate improvement in radial height, inclination, and volar tilt are significantly decreased by the time. Others problems are pin site complications include infection, loosening, and interference with extensor tendon gliding and superficial radial nerve injury.

POSTOP EVALUATION

The evaluation of the patient post operatively was carried methodically after 3months and 6 months. Both radiological and functionally assessment was carried out.

POSTOP RADIOLOGICAL EVALUATION:

Standard anteroposterior and lateral views were taken to assess fracture pattern and to assess the parameters like palmar tilt, radial height, radial inclination, residual deformity. The 22 degree - tilted lateral view was also taken to assess any residual depression of the palmar lunate facet.

The radiological evaluation was performed with

ANATOMICAL EVALUATION

SARMIENTO'S MODIFICATION OF LINDSTROM'S CRITERIA.

	DEFORMITY	RESIDUAL DORSAL TILT	RADIAL SHORTENING	LOSS OF RADIAL INCLINATION
EXCELLENT	No or insignificant	0^0	< 3 mm	$< 5^0$
GOOD	Slight	1^0 to 10^0	3 to 6 mm	5^0 to 9^0
FAIR	Moderate	11 to 14	7 to 11 mm	10^0 to 14^0
POOR	Severe	Atleast 15^0	Atleast 12 mm	$>14^0$

FUNCTIONAL EVALUATION:

All patients were reviewed by a single observer. Clinical assessment included time to return to work, presence of wrist pain, range of motion, loss of alignment and radial height.

Radiographs were reviewed once in 4 weeks, for fracture union and to assess fracture alignment. Bony union was defined in both clinical and radiological terms with radiological evidence of bridging trabeculae across the fracture site and disappearance of the fracture line in both anteroposterior and lateral views and clinically by normal activities without pain.

The functional outcome of the patients was evaluated with Mayo Wrist Score.

MAYO WRIST SCORE

Category	Score (points)	Findings
Pain (25 points)	25	None
	20	Mild, occasional
	15	Moderate, tolerable
	0	Severe or intolerable
Functional status (25 points)	25	Returned to regular employment
	20	Restricted employment
	15	Able to work but unemployed
	0	Unable to work because of pain
Range of motion (25 points)		Percentage of normal
	25	100
	15	75–99
	10	50–74
	5	25–49
	0	0–24
		Dorsiflexion-plantar flexion arc (injured hand only)
	25	≥120°
	15	91–119°
	10	61–90°
	5	31–60°
	0	≤30°
Grip strength (25 points)		Percentage of normal
	25	100
	15	75–99
	10	50–74
	5	25–49
	0	0–24
Final result		
Excellent	90–100	
Good	80–89	
Fair	65–79	
Poor	<65	

MATERIALS AND METHODS

This study was designed toanalyze and compare the functional and radiographic outcome in distal radius articular fractures of 27 patients treated by closed reduction through bridging external fixator augmented with K-wires and volar-locking plating done in our Institute of Orthopaedics and Traumatology, Madras Medical College and Rajiv Gandhi Government General Hospital over a period of 2 years and 2 months from July 2012 to September 2014.

During this period, fractures of distal radius in skeletally matured patients were managed primarily by internal fixation with Locking compression plate or External fixator optionally augmented with K-wires.

The criteria for patient selection were as follows;

INCLUSION CRITERIA:

1. Age more than 18 years.
2. Muller's type B (partial intra-articular) and type C (complete intra-articular)
3. Intra-articular fractures extending less than 5 cm from joint line
4. Closed fractures.

EXCLUSION CRITERIA:

1. Age less than 18 years.
2. Undisplaced fracture.
3. All open fractures.
4. Neglected fractures more than 4 weeks.
5. Severe co-morbidities.
6. H/O previous wrist pathology or malunited distal radius fracture.

Patients of both sexes were recruited in the study according to the devised inclusion and exclusion criteria.

PATIENT EVALUATION:

Patients presenting in the Emergency department and the Outpatient department were admitted for thorough evaluation. Detailed history was taken to rule out other systemic injury, ascertain the duration of injury, mode of injury, co morbid illness, and history of previous surgeries and for ruling out other major system involvement as a part of trauma screening.

The involved limb is evaluated for the injuries pertaining to skin in the form of abrasions, contusion, lacerations, punctured wounds etc. Diagnosis of fracture was done clinically with the help of tenderness, swelling, deformity and abnormal mobility (rarely). Vascular examination of the distal forearm, hand and palpation of radial artery and ulnar artery pulses (by Allen test) in particular were done. Allen test is used to detect patency of radial, ulnar and digital arteries. Neurological examination of all peripheral nerves is done with particular attention to median nerve considering its propensity to get injured because of its anatomical position.

Careful evaluation of the features of impending or established compartment syndrome was done for ruling out those fractures from the study. Specialist opinion to rule out other injuries was got. All eligible patients fulfilling our inclusion criteria were subjected to further radiological evaluation.

PREOPERATIVE ASSESSMENT:

The limb was stabilized in a below - Elbow slab temporarily and limbelevated to reduce the pain and swelling. Further investigations were done for anaesthetist opinion and assessment obtained. All patients included in thestudy were subjected to the described surgical procedure, after surgicalfitness was obtained.

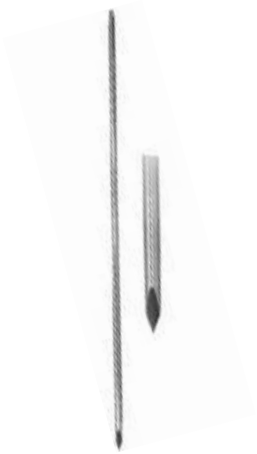
SURGICAL PROCEDURE:

All internal fixations were performed in the Institute of Orthopedics and Traumatology, Rajiv Gandhi Government General Hospital & Madras Medical College, Chennai. The fractures were treated with internal fixation or external fixation for the distal radius intraarticular fractures. The patients were randomized alternatively into 2 groups and were operated by internal or external fixation.

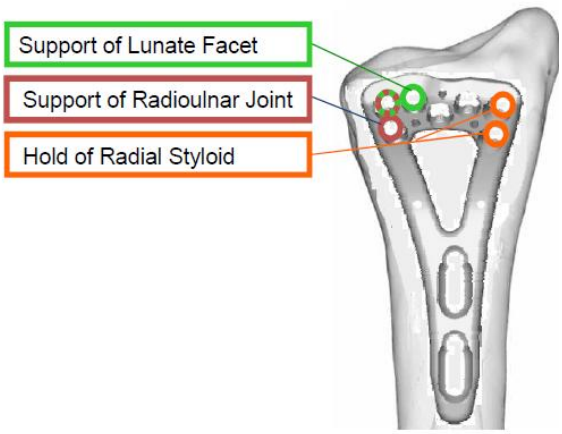
PREOPERATIVE PLANNING

The choice of a particular procedure for each case depended on the Fracture pattern, reducibility and stability and quality of bone. The

range of armamentorium for distal radius is 2-column volar Locking compression plate to external fixator optionally augmented with Kirschner wires.



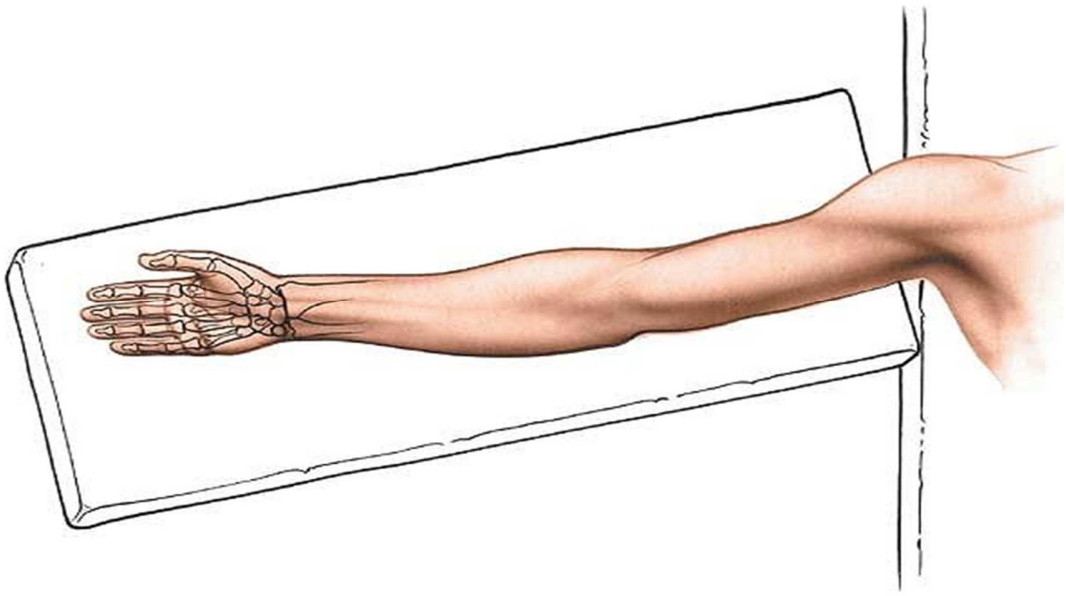
Various implants 2.4mm LCP, 1.6mm 1.8mmKirschnerwire, Radial external fixator (ligamentotaxis)



2- COLUMN VOLAR LCP FUNCTIONALITY

PATIENT POSITIONING

Patient was positioned supine on the radiolucent table with side arm-board. Image intensifier was positioned under the arm-board so as to visualise the distal radius, distal ulna and the articular surface in AP and lateral views.



SURGICAL TECHNIQUE:

All procedures were performed under general or regional anaesthesia

(supraclavicular or interscalene block). Our standard practice was performed under sterile aseptic precautions of local parts preparation and draping. Routinely preoperative prophylactic intravenous cefotaxime was administered for all patients.

Tourniquet was used in 7 patients and hemostasis was achieved in all patients before closing the surgical wound.

All the patients were approached by standard volar approach for distal radius except for three, where closed reduction was done and external fixator was applied and augmented with Kirschner wire or screws.

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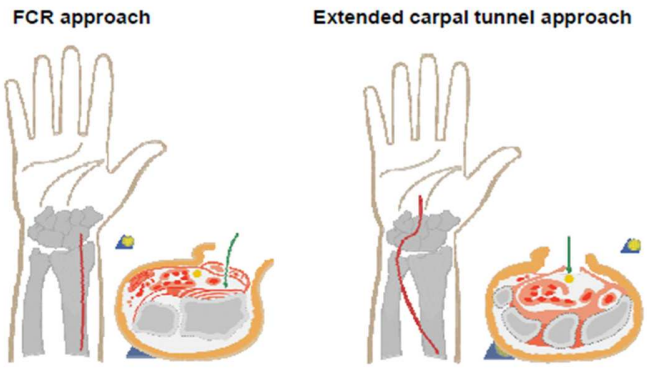
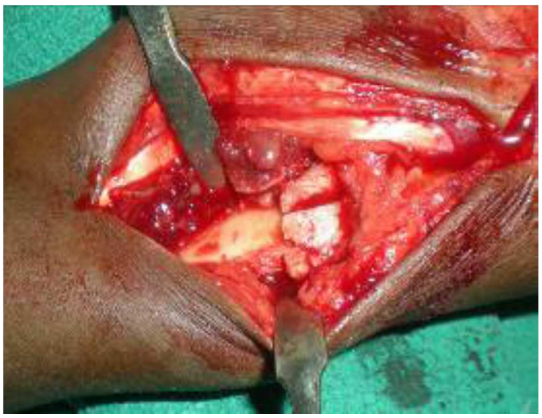


The standard modified Henry's volar approach was undertaken to fix the fragments of thedistal radius. In cases where the radial column fragment was initially approached, the plane between the radial artery and the flexor carpi radialis was used. For the intermediate column fragment under the lunate facet,plane between the flexor carpi radialis tendon and the median nerve wasused. The distal and lateral borders of pronator quadratus were erased and retracted ulnarward.

INTRA OPERATIVE PICTURES OF THE EXPOSURE OF THE DISTAL RADIUS



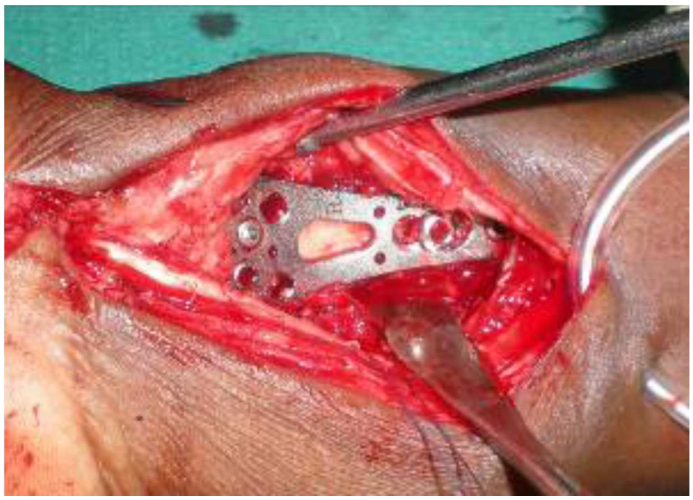
Closed reduction and external fixation was done for those with skin conditions not permitting for open reduction.

Open reduction was performed using intrafocal leverage, traction, and temporary fixation with Kirschner wires followed by definitive fixation with the implants of choice.

In cases which had a displaced radial styloid or fragments too small for othermeans of fixation, was fixed with Kirschner wires augmented with externalfixator

.

Locking compression plates with 2.4 mm were used forcomminuted fractures with relatively poor bone quality.



Intra operative picture of Distal Radius with LCP

Bone grafting wasnot donein any of the cases in spite of the higher degree of comminution in high number of patients as all of them had good bone inthe volar intermediate column[16].

The reduction of both the distal radius were confirmed with the image intensifier during the fixation and ensured before closure of the surgical site.

Drain was used in all of our Volar LCP internally fixed patients.

POSTOP PROTOCOL:

All patients were given I.V third generation cephalosporin during inductionwhich was continued for 3-5 days post operatively. The hand and forearmwas initially placed in a compressive dressing extending from hand to belowelbow and elevated for forty-eight to seventy-two hours to reduce swelling. Drain was removed on the 2nd postoperative day.

All patients operated with Volar LCP were encouraged to begin an early active range of motion of thewrist and hand as tolerated. The patients fixed with Kirschner wire augmented External fixatorwere immobilized for four to six weeks based on the fracture pattern, reduction and stability, with active finger mobilization. Thereafter gradual wrist mobilization was initiated only. Sutures were removed on the twelfthpost-operative day. Patients were not allowed to lift heavy weight for twelveto sixteen weeks.

Mobilization of the wrist and the hand were initiated from the 2ndpostoperative day as tolerated by the patient except for those fixed with External fixator or Kirschner wires alone. Those patients fixed with K wires were initially given below elbow cast and was mobilized by 3-6 weeks, after the removal of the cast.

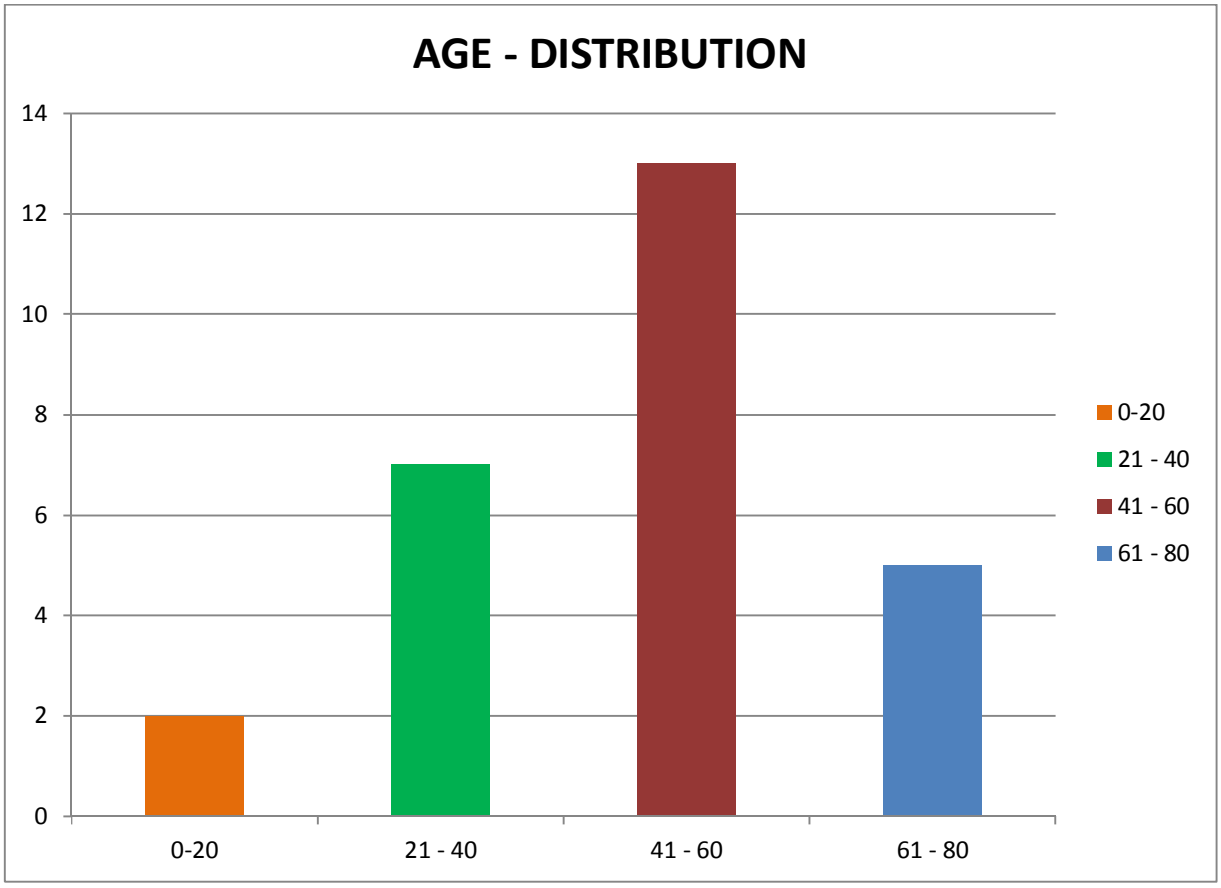
OBSERVATION AND RESULTS

The following observations were made in the study.

AGE INCIDENCE:

Patients' age ranged from 18 to 70 years. Average: 47.18 years

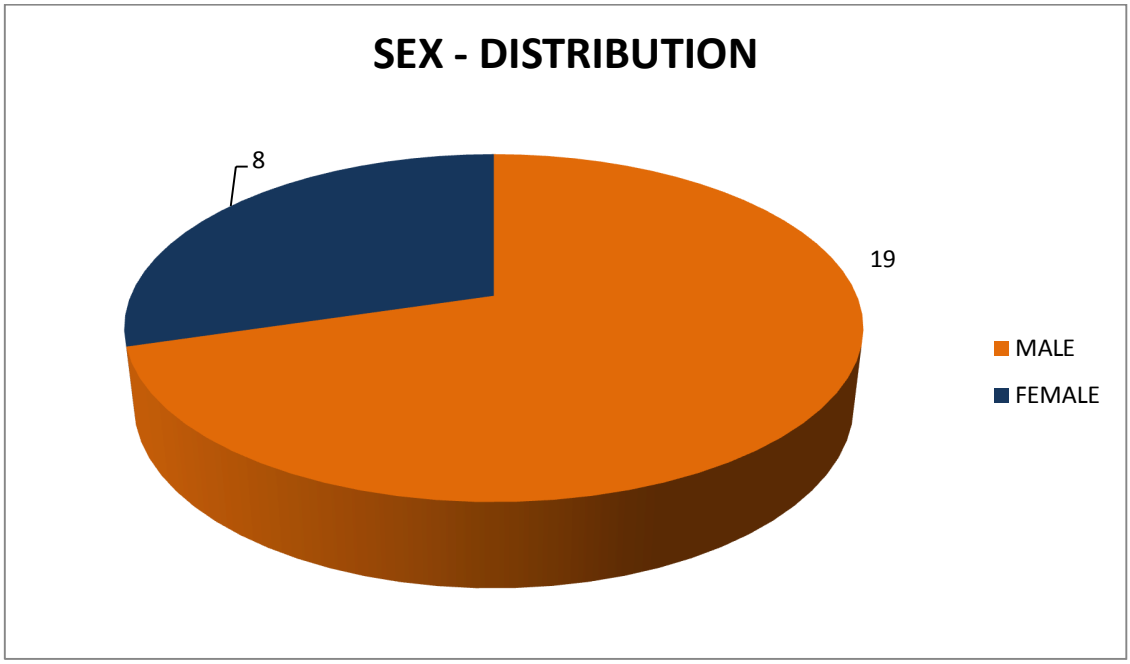
AGE – DISTRIBUTION	
AGE IN YEARS	NO OF PATIENTS
0-20	2
21 – 40	7
41 – 60	13
61 – 80	5



SEX INCIDENCE:

In our series, Males predominated with the ratio of 2.3:1

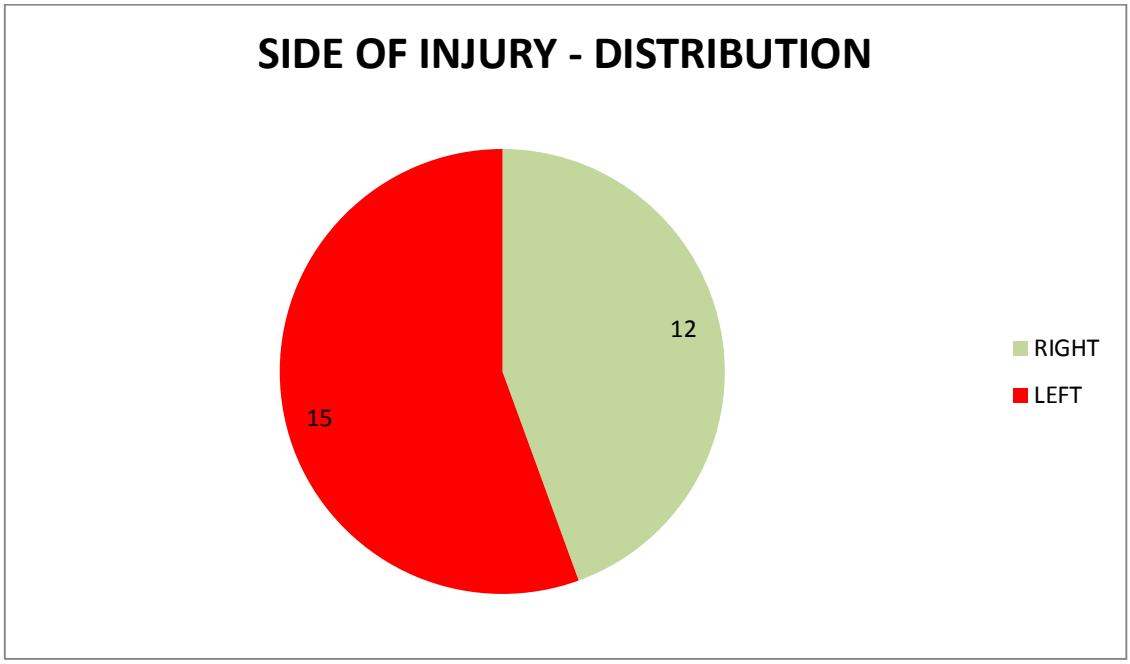
SEX - DISTRIBUTION	
SEX	NO OF PATIENTS
MALE	19
FEMALE	8



SIDE OF INJURY

In our study 15 patients had Left sided injury accounting for 55.5% of the totalpatients.

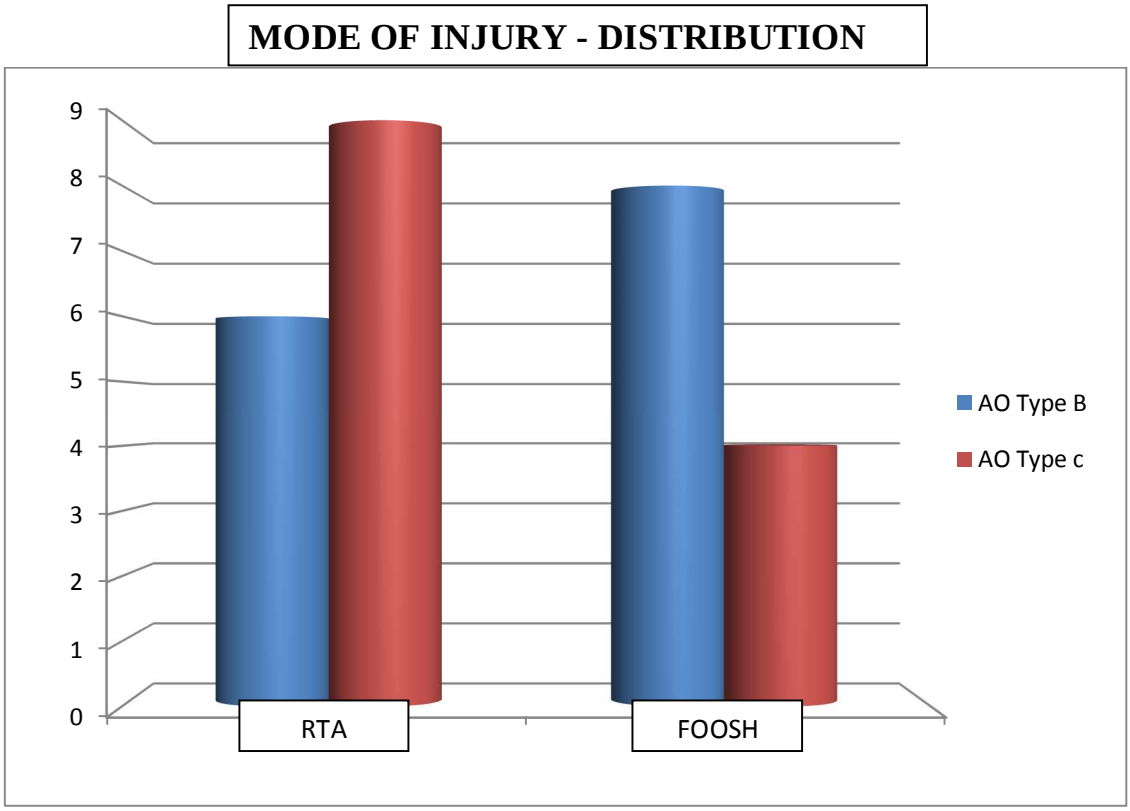
SIDE - DISTRIBUTION	
SIDE	**NO OF PATIENTS**
RIGHT	12
LEFT	15



MODE OF INJURY

In our series **RTA** was the predominant mode of injury.

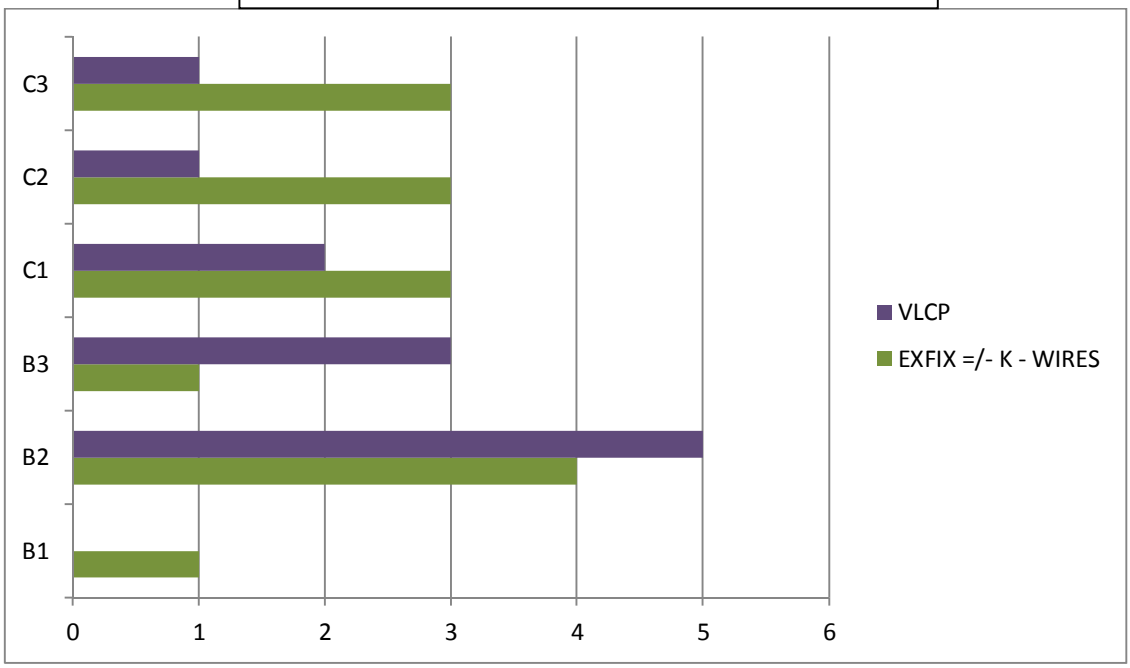
Type of trauma	AO Type B	AO Type c	Total
RTA	6	9	15
FOOSH	8	4	12
Total	14	13	



FRACTURE CLASSIFICATION

MULLER AO TYPE	EXT FIXATOR WITH K-WIRE GROUP	VOLAR LCP GROUP
B1	1	0
B2	4	5
B3	1	3
C1	3	2
C2	3	1
C3	3	1

MODE OF FIXATION DISTRIBUTION



Only 8 of the 27 patients presented with significant co-morbid illness in theform of Diabetes Mellitus or Systemic Hypertension which were adequatelycontrolled prior to surgery.

All patients belonged to lower to middle socioeconomic strata of the society withmoderate built and nourishment.

Twelve patients had associated skeletal injuries which were treated appropriately.

ASSOCIATED INJURIES	
TYPE OF INJURY	**NO OF PATIENTS**
# Shaft of femur ipsilateral	2
# Both bone leg ipsilateral	2
# Dorsolumbar vertebra	0
# Dislocation cervical vertebra	1
# Pelvis (pubic ramii)	1
Crush injury contralateral arm	1
Crush injury contralateral leg	0
Crush injury ipsilateral hand	1
# Proximal humerus contralateral	1

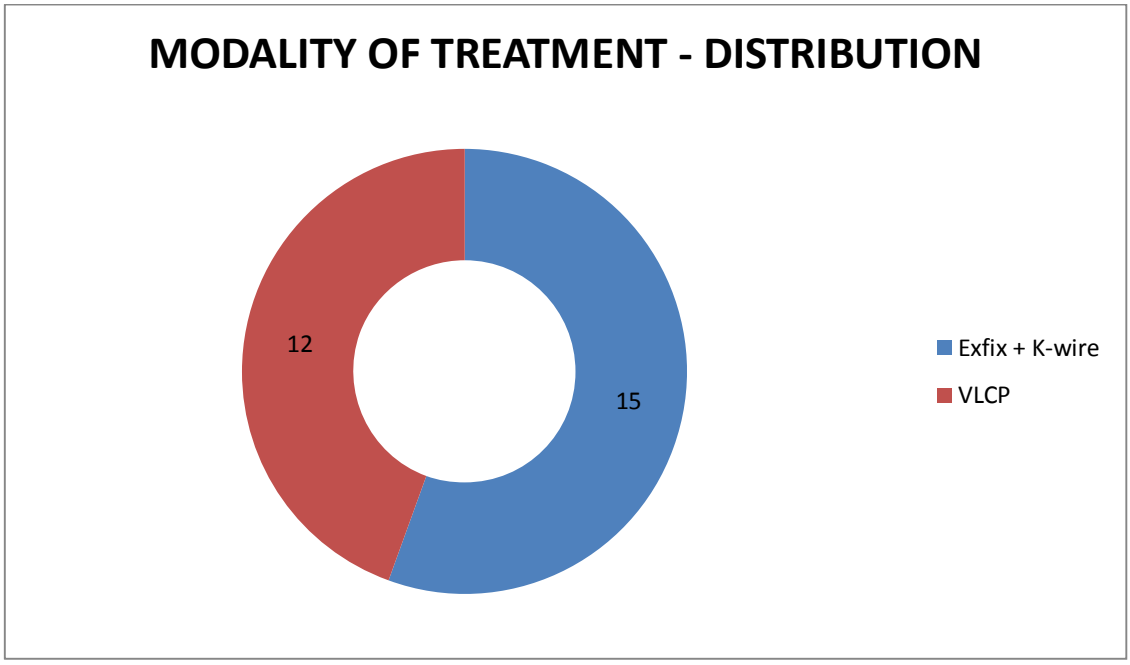
None of the patients had any other major organ involvement.

Neurovascular status was intact in all the patients under study.

The average delay in surgery in our study was 5.3 days and the range was 12 hours to 28 days.

DELAY IN SURGERY	
No of days	No of patients
0 – 5 days	21
6 – 15 days	4
16 - 28 days	2

In the modality of treatment, 12 patients were treated with volar locking compression plate and 15 patients were treated with external fixation augmented by K-wires.



RESULTS:

The mean follow up was 8.9 months, ranging from 3 months to 24 months.All 27 patients had regular follow-up.

UNION:

All the patients had good union.The mean time of union was 14 weeks with a range of 10 to 18 weeks with a 16 cases healing by 12 weeks. Restof the 11cases took a longer duration. 1 case of delayed union was reported in the external fixator group when the external fixator was removed and a cast was applied for a further 2 months till union was complete . Longer duration to union is noted in patients of older age withrelatively poor bone quality.

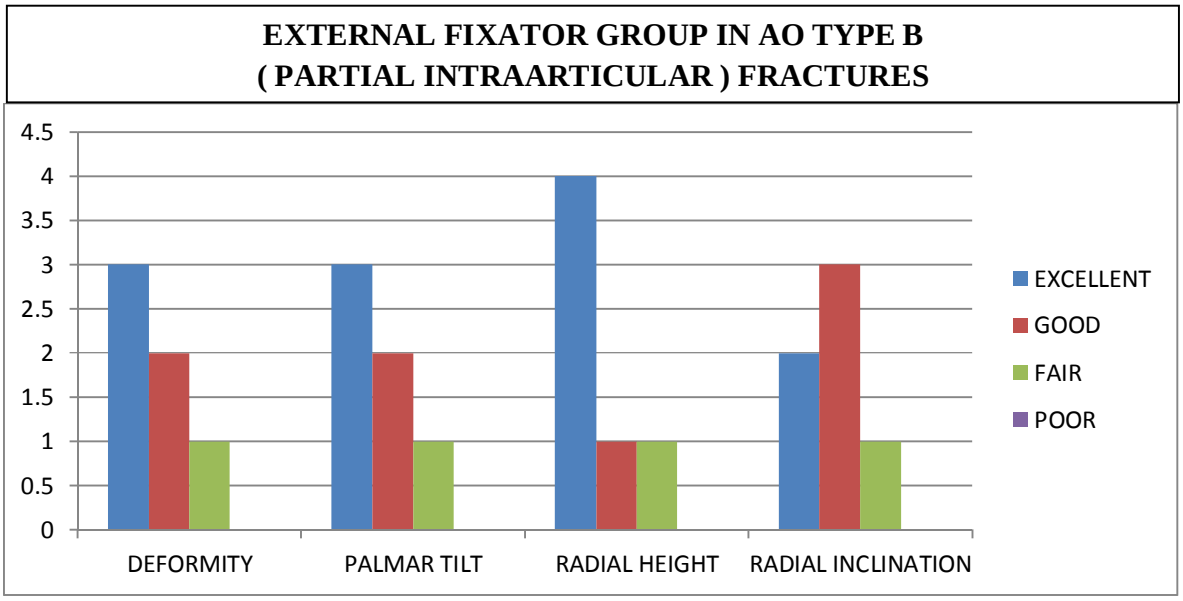
MALUNION:

3 patients of the 15 treated with kirschner wire augmented External fixator had malunion with significant dorsal angulation with negative palmar tilt.

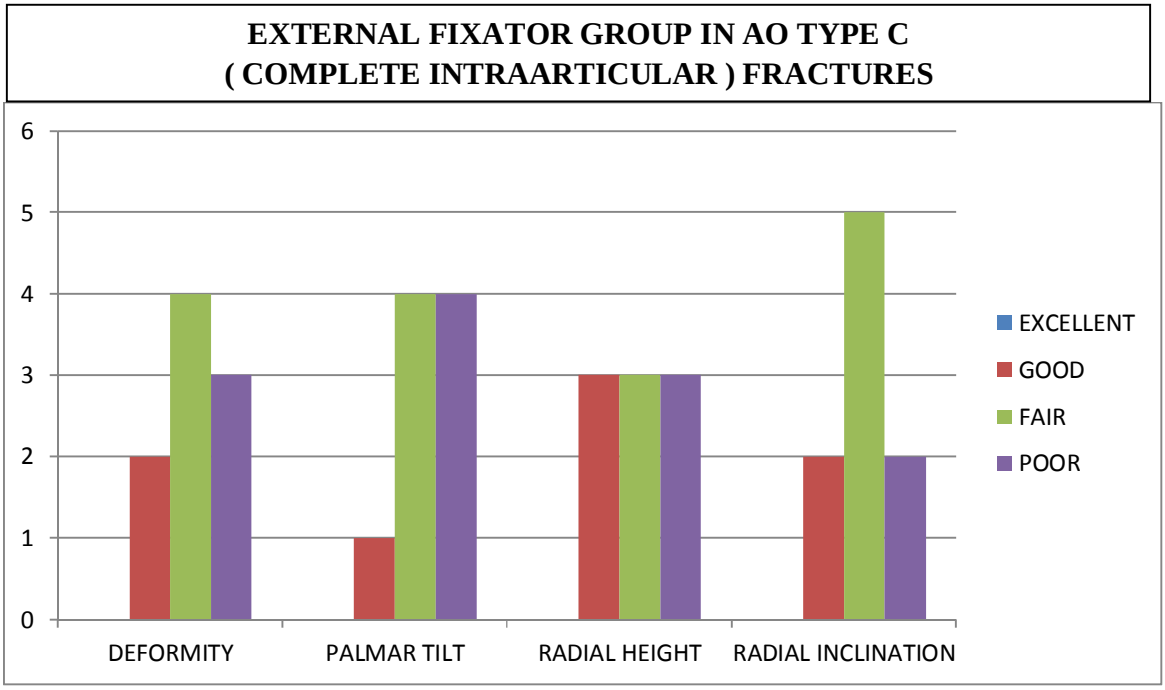
RADIOLOGICAL OUTCOME :

Sarmiento's modification of Lindstorm's criteria :

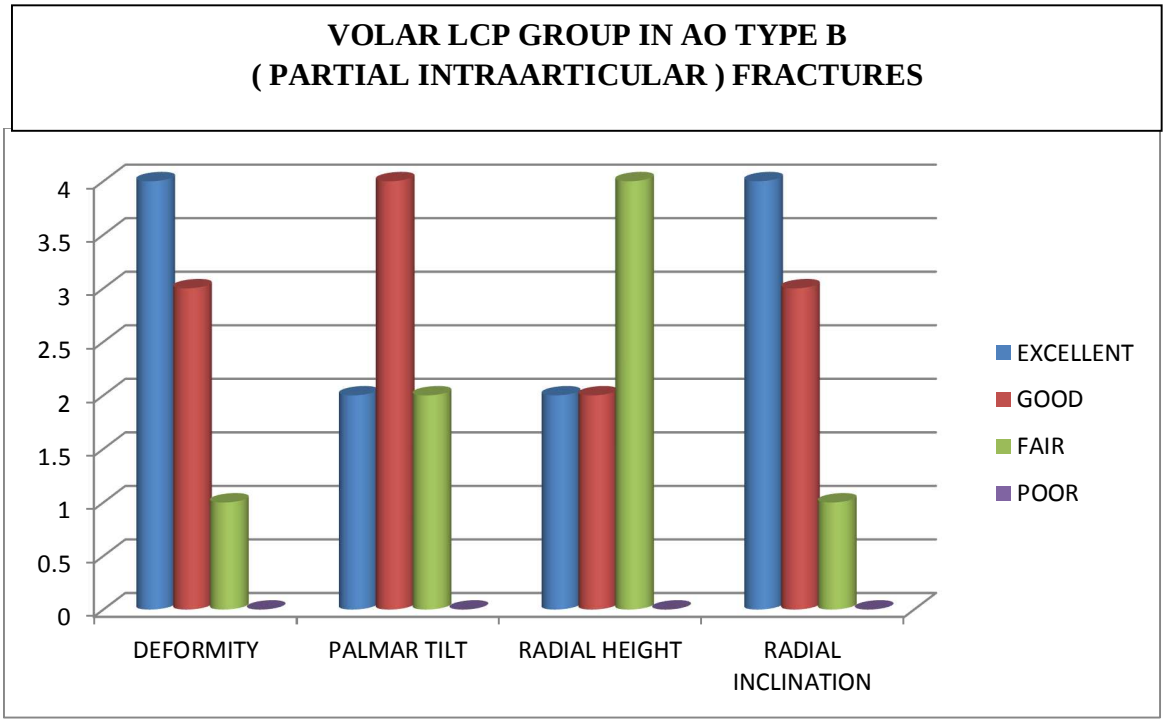
EXTERNAL FIXATOR GROUP IN AO TYPE B (PARTIAL INTRAARTICULAR) FRACTURES					
RESULT	**DEFORMITY**	**PALMAR TILT**	**RADIAL SHORTENING**	**RADIAL INCLINATION**	**MEAN**
EXCELLENT	3	3	4	2	3 (50%)
GOOD	2	2	1	3	2(34 %)
FAIR	1	1	1	1	1(17%)
POOR	0	0	0	0	0



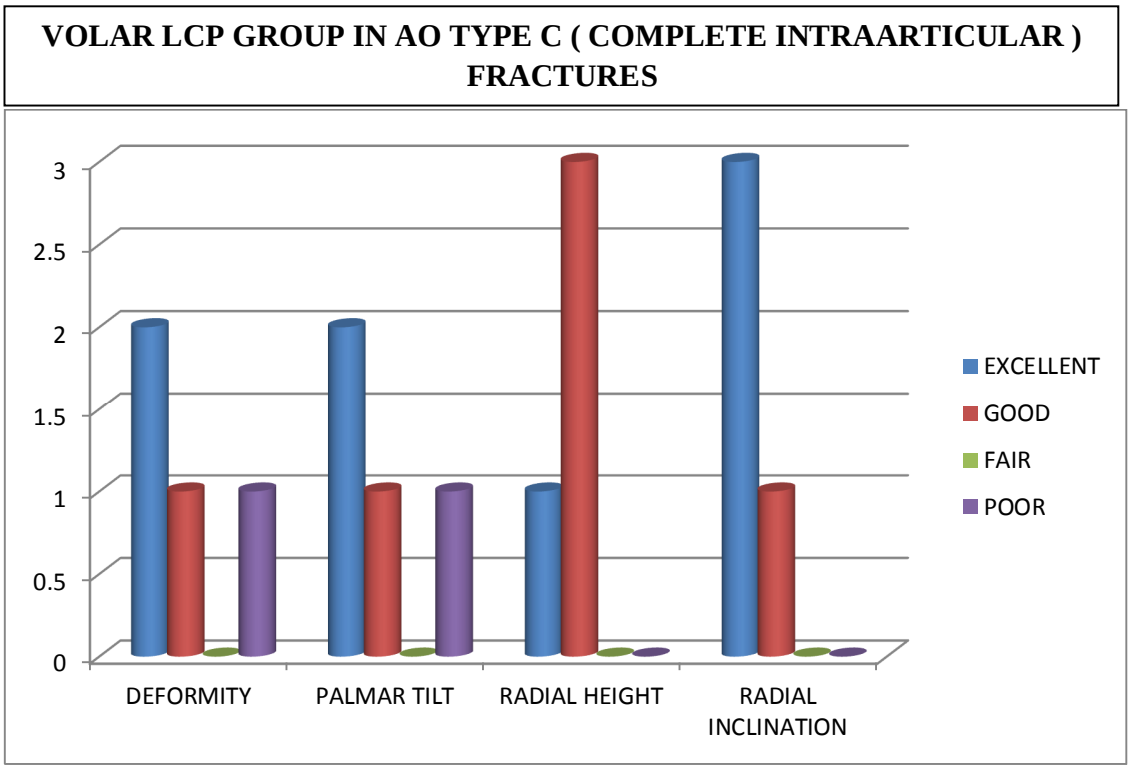
EXTERNAL FIXATOR GROUP IN AO TYPE C (COMPLETE INTRAARTICULAR) FRACTURES					
RESULT	**DEFORMITY**	**PALMAR TILT**	**RADIAL SHORTENING**	**RADIAL INCLINATION**	**MEAN**
EXCELLENT	0	0	0	0	0
GOOD	2	1	3	2	2(22%)
FAIR	4	4	3	5	4(45%)
POOR	3	4	3	2	3 (33%)



VOLAR LCP GROUP IN AO TYPE B (PARTIAL INTRAARTICULAR) FRACTURES					
RESULT	**DEFORMITY**	**PALMAR TILT**	**RADIAL SHORTENING**	**RADIAL INCLINATION**	**MEAN**
EXCELLENT	4	2	2	4	3(37.5%)
GOOD	3	4	2	3	3 (37.5%)
FAIR	1	2	4	1	2 (25%)
POOR	0	0	0	0	0



VOLAR LCP GROUP IN AO TYPE C (COMPLETE INTRAARTICULAR) FRACTURES					
RESULT	**DEFORMITY**	**PALMAR TILT**	**RADIAL SHORTENING**	**RADIAL INCLINATION**	**MEAN**
EXCELLENT	2	2	1	3	2(50%)
GOOD	1	1	3	1	1.5 (37.5%)
FAIR	0	0	0	0	0
POOR	1	1	0	0	0.5 (12.5%)



FUNCTIONAL SCORE FOR AO TYPE B (PARTIAL INTRAARTICULAR) FRACTURES		
	Ext fixator with K-wire group	Volar LCP group
Excellent	3	3
Good	2	3
Fair	1	2
Poor	0	0

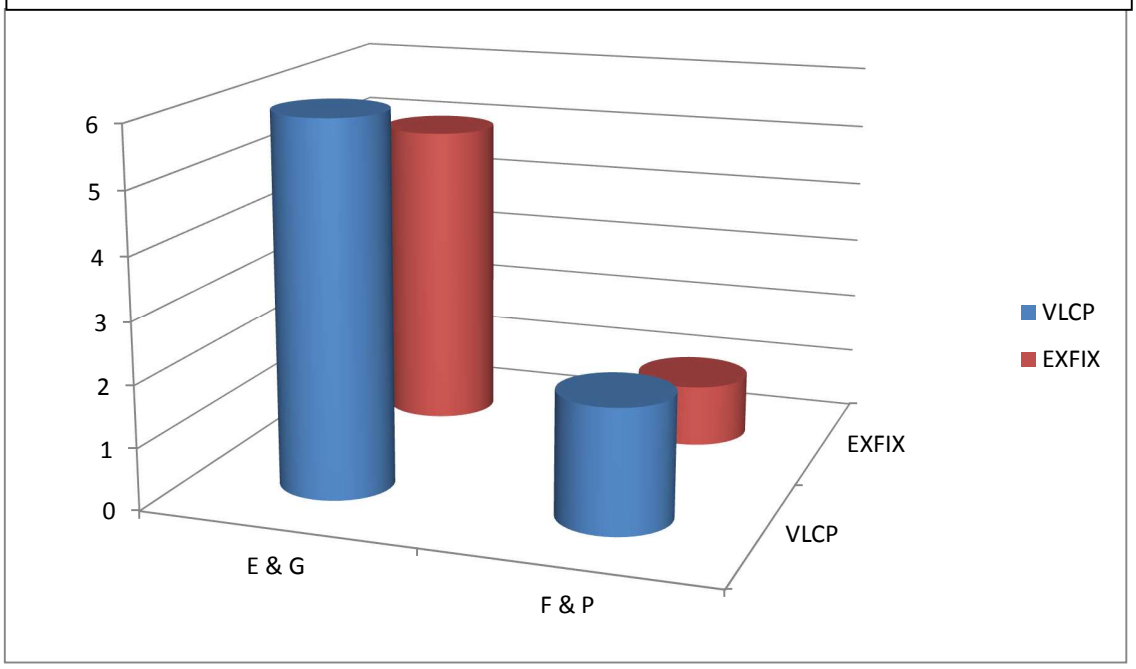
Calculation of significance values :

	E & G	F & P	*Marginal Row Totals*
EXFIX	5 (4.71) [0.02]	1 (1.29) [0.06]	6
VOLAR LCP	6 (6.29) [0.01]	2 (1.71) [0.05]	8
Marginal Column Totals	11	3	14 (Grand Total)

The Chi-square statistic is 0.1414. The P value is 0.706879. This result is *not* significant at $p < 0.05$.

This denotes that there is no significant difference in the radiological outcome of modality of fixation of distal radius partial intraarticular fractures by Volar LCP and External Fixator.

FUNCTIONAL SCORE FOR AO TYPE B (PARTIAL INTRAARTICULAR) FRACTURES



FUNCTIONAL SCORE FOR AO TYPE C (COMPLETE INTRAARTICULAR) FRACTURES		
	Ext fixator with K-wire group	Volar LCP group
Excellent	0	2
Good	2	2
Fair	4	0
Poor	3	0

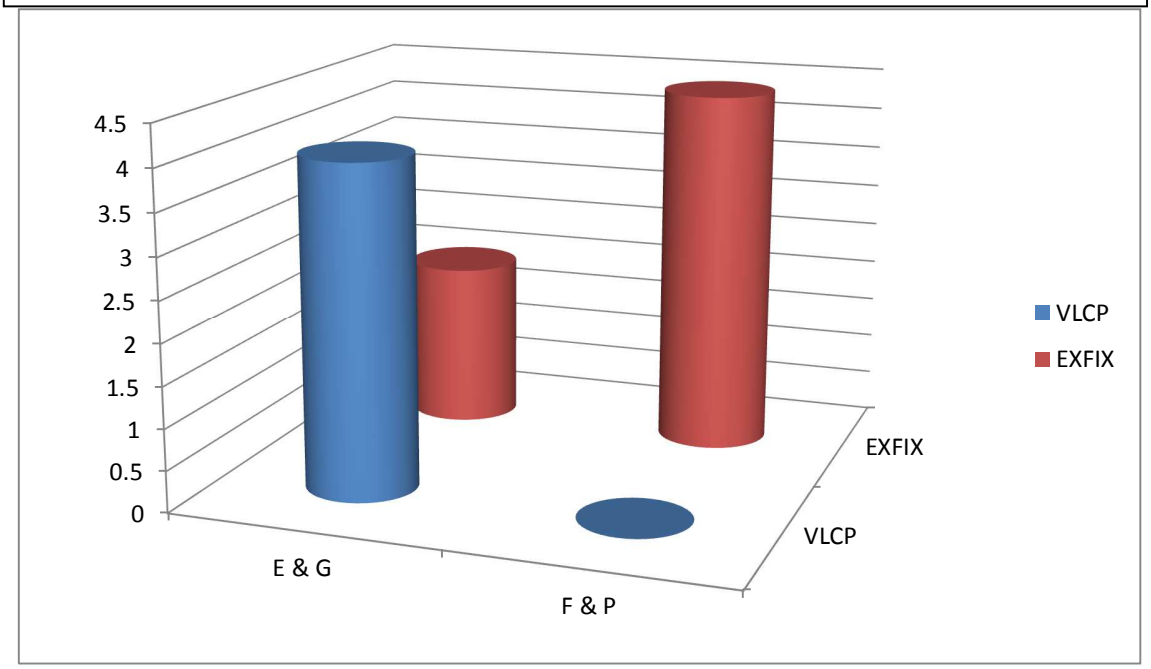
Calculation of significance values

	E & G	F & P	*Marginal Row Totals*
EXFIX	2 (4.15) [1.12]	7 (4.85) [0.96]	9
VOLAR LCP	4 (1.85) [2.51]	0 (2.15) [2.15]	4
Marginal Column Totals	6	7	13 (Grand Total)

The Chi-square statistic is 6.7407. The P value is 0.009424. This result is significant at $p < 0.05$.

This denotes that there is significant difference in the radiological outcome of modality of fixation of distal radius complete intraarticular fractures by Volar LCP and External Fixator.

FUNCTIONAL SCORE FOR AO TYPE C (COMPLETE INTRAARTICULAR) FRACTURES



COMPLICATIONS:

Two of our patients had malunion. Four of our patients had prominent wires that were felt subcutaneously onthe ulnar side. None of the four had any functional disturbance or painbecause of the same.

One of our patients had superficial infection which warranted early removal of K-wire leading to malunion. The infection was controlled by removal of K-wire and antibiotics.

Stiffness of the wrist joint and the hand was noted in four patients who werereluctant in mobilizing and attending physiotherapy sessions. In the Volar LCP group, two patientswho were immobilized in cast postoperatively had transient stiffness whichwas overcome with aggressive physiotherapy resulting in good range ofmotion thereafter.

None of the patients in the present study presented with iatrogenic neurovascular injury or implant breakage during the period of follow-up.

COMPLICATIONS ASSOCIATED WITH THE STUDY		
COMPLICATIONS	**EXT FIXATOR GROUP**	**VOLAR LCP GROUP**
Reflex sympathetic dystrophy	NIL	NIL
Paraesthesia in distribution of radial nerve	3	NIL
Impingement of tendons	NIL	NIL
Median nerve complications	NIL	NIL
Residual pain	2	NIL
Dorsal angulation	3	NIL
Pin tract & wound infection	3	3
Pin loosening	2	NIL
Restricted wrist movements	3	2
Finger stiffness	1	NIL
Arthritis	4	1
Malunion	3	1

FUNCTIONAL OUTCOME:

SUBJECTIVE EVALUATION OF PATIENTS BY MAYO SCORE

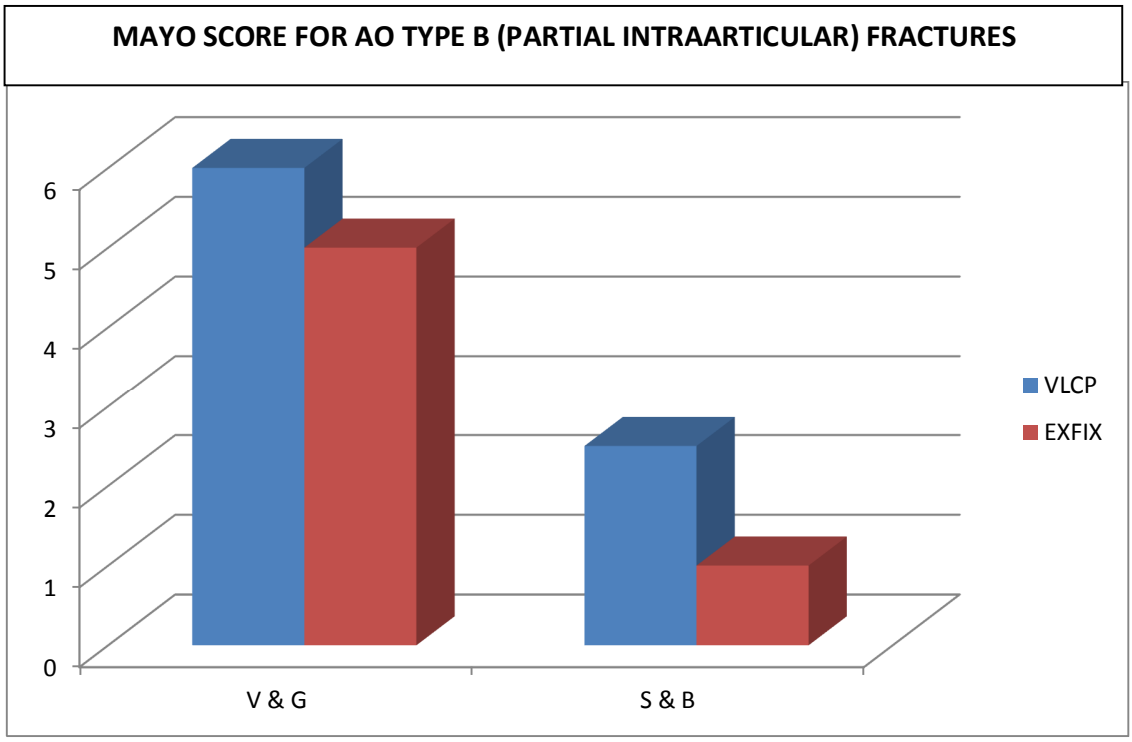
MAYO SCORE FOR AO TYPE B (PARTIAL INTRAARTICULAR) FRACTURES		
	Ext fixator with K-wire group	Volar LCP group
Very Good (90 – 100)	4	4
Good (80- 89)	1	2
Satisfactory (65 – 79)	1	2
Bad (less than 65)	0	0

Calculation of significance values :

	V & G	S & B	*Marginal Row Totals*
EXFIX	5 (4.71) [0.02]	1 (1.29) [0.06]	6
VOLAR LCP	6 (6.29) [0.01]	2 (1.71) [0.05]	8
Marginal Column Totals	11	3	14 (Grand Total)

The Chi-square statistic is 0.1414. The P value is 0.706879. This result is *not* significant at $p < 0.05$.

This denotes that there is no significant difference in the functional outcome of modality of fixation of distal radius partial intraarticular fractures by Volar LCP and External Fixator.



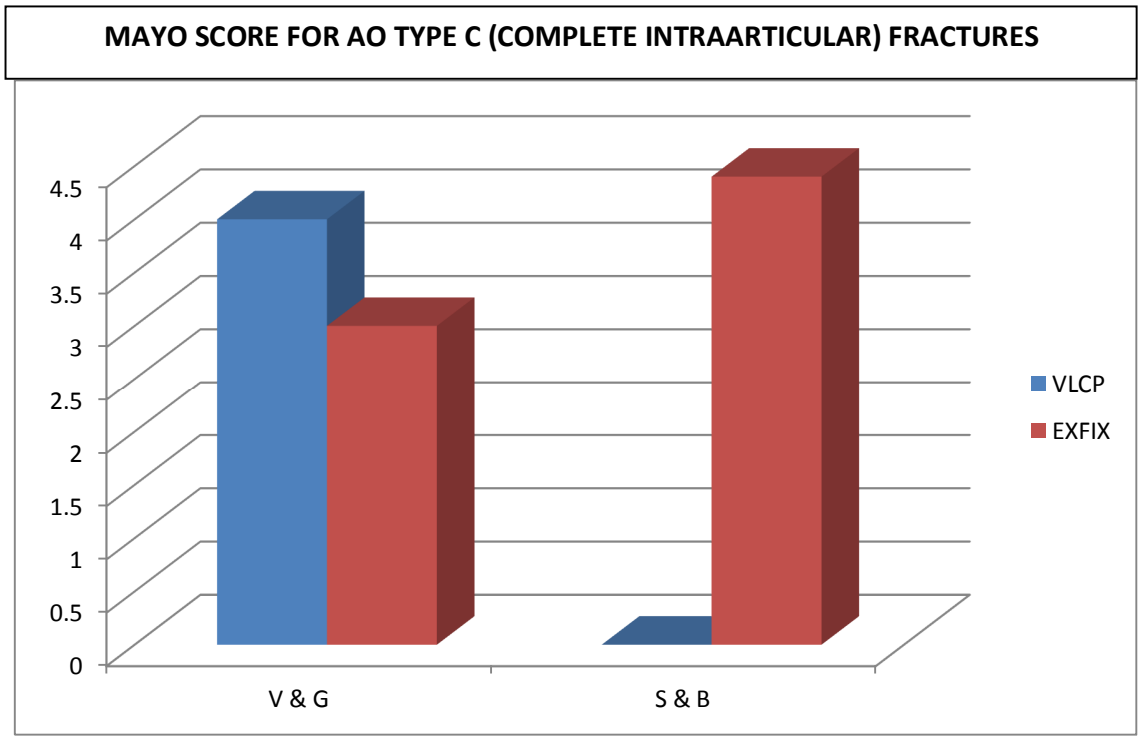
MAYO SCORE FOR AO TYPE C (COMPLETE INTRAARTICULAR) FRACTURES		
	Ext fixator with K-wire group	Volar LCP group
Very Good (90 – 100)	0	1
Good (80- 89)	3	3
Satisfactory (65 – 79)	3	0
Bad (less than 65)	3	0

Calculation of significance values :

	V & G	S & B	*Marginal Row Totals*
EXFIX	3 (4.85) [0.7]	6 (4.15) [0.82]	9
VOLAR LCP	4 (2.15) [1.58]	0 (1.85) [1.85]	4
Marginal Column Totals	7	6	13 (Grand Total)

The Chi-square statistic is 4.9524. The P value is 0.026055. This result is significant at $p < 0.05$.

This denotes that there is no significant difference in the functional outcome of modality of fixation of distal radius complete intraarticular fractures by Volar LCP and External fixator.



DISCUSSION

The rise of intra articular distal radius fractures and its various presentations of complexity in even younger individuals are predominantly due to high energy trauma especially road traffic accidents.

In our study, around 55.5% of patients are due to RTA and presented with polytrauma at the emergency ward. The exact incidence and demography of distal radius intra-articular fractures have not been cited in the literature. In our study 13 of 27 cases (48%) are type Cdistal radius fractures.

COMPARISON OF AGE DISTRIBUTION			
	Minimum age in years	Maximum age in years	Average age in years
Jupiter et al	16	76	43
Louis Catalano et al	17	42	30
Orbay J et al	18	75	59
Anakwe et al	19	56	48
Our study	18	70	47.18

The average mean age of our study is comparable to the one by Anakwe and Jupiter who had an average age of 48 and 43 years respectively.

Our study had a male predominance with 19 of 27 cases

COMPARISION OF SEX RATIO		
	Males (%)	Females (%)
Jupiter et al	60	40
Louis Catalano et al	67	33
John K Bradway et al	56	44
Our study	70	30

Our study's male predisposition of 70 % is comparable to Louis Catalano et al which was 67%. The higher incidence among the males could be attributed to a highly active work group with a higher involvement in high energy trauma and high velocity injuries of RTA

In our study left side (non-dominant) was involved in 15 of the 27 study cases.

COMPARISON OF SITE DISTRIBUTION		
	Right (%)	Left (%)
Jupiter et al	61	39
Louis Catalano et al	48	52
John K Bradway et al	50	50
Walz et al	48	52
Our study	45	55

Our study's non-dominant Left-side predisposition of 55 % is comparable to Louis Catalano et al and Walz et al which was 52%. The relatively more predisposition could be attributed to a less- protective and late defense mechanism when fall on the left side or using left hand

In our study RTA formed the reason of trauma in 15 of the 27 study cases.

COMPARISION OF MODE OF TRAUMA			
	RTA (%)	FOOSH (%)	OTHERS (%)
Jupiter et al	67	33	0
Louis Catalano et al	10	67	24
F Fitoussi & SP Chow	79	9	12
Anakwe et al	10	90	0
Our study	55	45	0

Our study's RTA trauma predisposition is 55 %. The reason for this nearly same incidence could be an older mean age of case study where a low-energy trauma is more frequent is causing a fracture on the outset of an osteoporotic bone.

All in our study belong to either type B or type C of distalradius fractures and graded the severity accordingly. 14 of Our 27 cases had sustained a complete intraarticular(AO type C) fracture. That is Type C fractureaccounted for 52% in our study

The fixed angled 2.4mm locking plates is the relatively newer choice ofimplant was used in all our patients, with maximum number of screws in the metaphyseal region in the desired direction of anchorage. Recent biomechanical and clinical studies whichwere undertaken for knowing the distal radius fixation revealed placement of locking screws in the metaphyseal bone with as close as 5mm close to the distal subchondral bone without violating its articular surface (59).

It became evident that morescrew placement in the distal metaphyseal acts as reefing technique.

The clinical assessment of the distal radioulnar joint becomes difficult in the emergency room setting but it can be assessed under anaesthesia after rigid fixation of the distal radius like piano key test.

Improved biomechanical understandings of the ligaments of the wrist led to the implementation of reefing technique, placement of plate more distally in volar aspect such that screws in the distal metaphyseal fragment will buttress the fragments well and prevent collapse of the articular comminution .

The latest concept among the various researches in distal radius fixation is the introduction of variable angle locking screws which as ply of 15 -20 degrees in all direction and also locks with the plate. The mean range of radiological evaluation of various studies was comparable with our study, as tabulated below.

COMPARISION OF RADIOLOGICAL EVALUATION			
	VA in degrees	RL in mm	RI in degrees
Jupiter et al	7	10	21
`Orbay J et al	13	10	21
F Fitoussi & SP Chow	3	9	20
Anakwe et al	10	11	20
Our study with VLCP	7.3	9.75	16.9
Our study with Exfix	2.9	5	14.2

Functional outcome after Fracture Union

The mean range of functional outcome of various studies was comparable with our study, as tabulated below.

COMPARISION OF RANGE OF MOVEMENTS				
	Palmar flexion	Dorsiflexion	Supination	Pronation
Jupiter et al	66	58	78	72
Orbay J et al	47	44	76	77
F Fitoussi & SP Chow	52	52	88	68
Anakwe et al	64	62	78	62
Our study with VLCP	77	69	76	64
Our study with Exfix	67	55	58	46

Objective Functional Outcome

Low energy fractures in elderly are being associated with good functional results but has many confounding variables.

The key aspects of the treatment are distal radius articular surface's anatomical reduction and achieving gooddistal radio ulnar congruity with an early mobilization for early rehabilitation.

In our study we had 27% of external fixator and 42% of Volar LCP associated with very good results based on Mayowrist score and are comparable to other studies as tabulated below.

COMPARISION OF FUNCTIONAL EVALUATION				
	Very good (%)	Good (%)	Satisfactory (%)	Bad (%)
Jupiter et al	63	20	17	-
Dennison et al	80	20	-	-
John K Bradway et al	44	12	44	-
Anakwe et al	24	60	16	-
Our study with VLCP	42	42	16	-
Our study with Exfix	26.6	26.6	26.6	20

Complications were at least and are comparable with standard studies. We had four patients with prominent wires, one case withsuperficial infection and 3 patients with wrist stiffness and 1 with finger stiffness.

In our study , among 15 external fixator cases, 3 had unstable distal fragments of distal radius , which needed to be augmented with additional K wirefixation and immobilization in above elbow slab for 4 weeks. Later itwas removed and immediate methodical wrist mobilization started.

The results of theVLCP subgroup patients were comparable to studies like Bradway et al but a vast majority (84 %) had good to very good functional score and satisfactory movement.

Primary internal fixation of the distal radius fixed with variable angle screws of volar locking plate facilitates earlymobilization and hence earlier return to activities with good range ofmovements, especially rotations.

CONCLUSION

From our study, we conclude that

- Conservative management or internal fixation with Kirschner wires alone for partial and complete intra-articular fractures of distal radiusis not sufficient.

- Early Primary fixation of the distal radius fractures by volar LCP is essential for good functional outcome and to avoid complication of prolonged immobilization, which facilitates early return to regular activities

  .

- Patients with unstable, either a dorsally or volarly displaced intraarticular radius fracture had excellent to good radiological outcome when treated with fixed angle volar locking plate

- With the above discussion, the fracture fixation with volar plate and screw system in the management of distal radius articular fractures, especially in type C (Complete intraarticular fractures) is a superior

method to maintain the reduction till union and prevent the collapse of the fracture fragments, even in grossly comminuted , unstable and osteoporotic bones ; as compared with external fixator augmented with K – wires.

- However in type B (partial intraarticular fractures) fractures, Volar LCP and K- wire augmented External fixator provide equivocal results and none is proved superior.

- Ligamentotaxis by external fixation provided favourable results in younger age group and in partial intra- articular type of distal radius fractures and requires atleast 4 cortical purchases on each side for effective stability.

- However long term follow-up is required to confirm our findings

CASE ILLUSTRATION– I

PRE OPERATIVE EVALUATION:

Name: Ramachandran

Age/ Sex: 47/M

IP No: 100946

Mode of injury: RTA

Time from injury to admission: 24 hours

Co-morbid illness: -

Associated injuries:-

Muller's classification and side: C3, Left side

SURGICAL EVALUATION:

Time delay from injury to surgery : 2days

Time delay from admission to surgery :2days

Position :Supine

Anaesthesia :GA

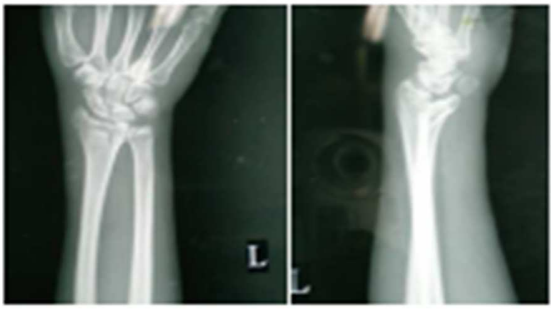
Radius approach : Extended Volar approach

Type of Radius fixation :Volar LCP

POST OPERATIVE EVALUATION :

Follow up period : 18 months Mayo wrist score : 95

Pre-op



Intra-op

Post-op

Follow-up: 6 month

CASE ILLUSTRATION - II

PRE OPERATIVE EVALUATION:

Name: Veeraraghavan

Age/ Sex: 55/m

IP No: 93266

Mode of injury: RTA

Time from injury to admission: 5 hours

Co-morbid illness: Diabetic

Associated injuries: -

Muller's classification and side: B2, Muller

SURGICAL EVALUATION:

Time delay from injury to surgery :4 days

Time delay from admission to surgery :4 days

Position :supine

Anaesthesia :GA

Radius approach :Volar Henry

Type of Radius fixation :Volar LCP

POST OPERATIVE EVALUATION :

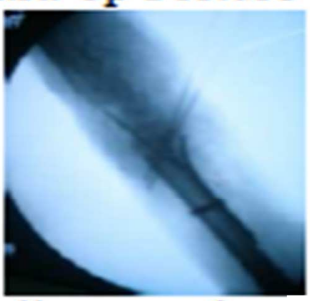
Follow up period :18 months

Mayo wrist score : 85

Pre-op

Post-op

Intra-op Picture



Follow up: 1yr

CASE ILLUSTRATION - III

PRE OPERATIVE EVALUATION:

Name: Rathi

Age/ Sex: 55/F

IP No: 47942

Mode of injury: RTA

Time from injury to admission: 10 hours

Co-morbid illness: Diabetic

Associated injuries: -

Muller's classification and side: C2

SURGICAL EVALUATION:

Time delay from injury to surgery : 1 day

Time delay from admission to surgery : 1 day

Position :Supine

Anaesthesia :RA

Radius approach : -

Type of Radius fixation :Exfix with K- wires

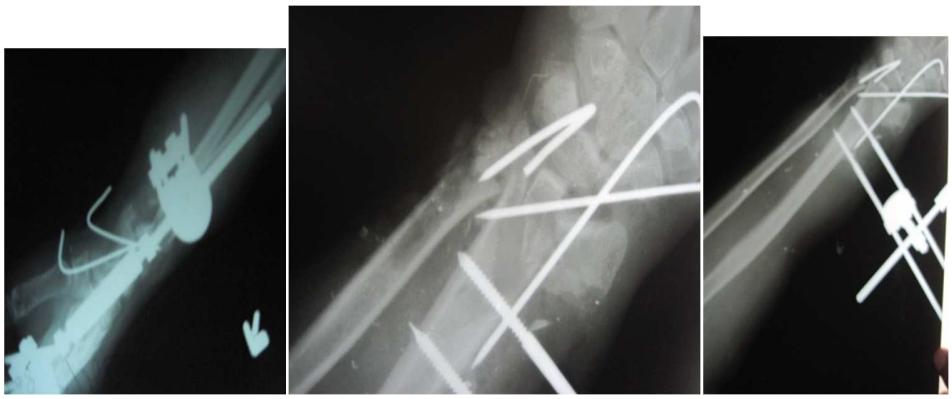
POST OPERATIVE EVALUATION :

Follow up period : 6 months

Mayo wrist score : 45

PRE- OP

POST- OP



4 MONTHS FOLLOW UP

FOLOW UP PHOTOS

CASE ILLUSTRATION - IV

PRE OPERATIVE EVALUATION:

Name: Sivaram

Age/ Sex: 35/M

IP No: 7813

Mode of injury: RTA

Time from injury to admission: 6 hours

Co-morbid illness: -

Associated injuries:-

Muller's classification and side:B2

SURGICAL EVALUATION:

Time delay from injury to surgery :1 day

Time delay from admission to surgery :1 day

Position :Supine

Anaesthesia :RA

Radius approach : Volar Henry

Type of Radius fixation :Exfix with K-wires

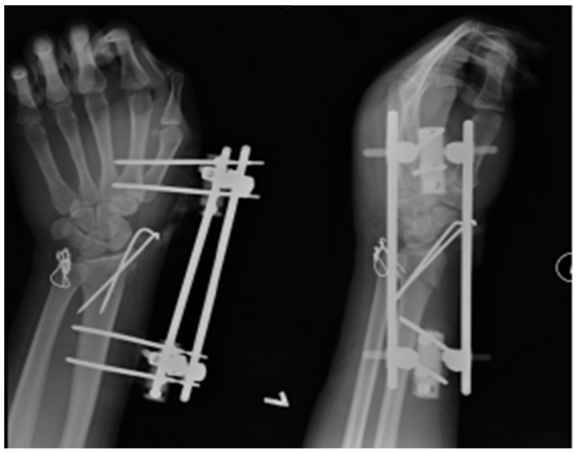
POST OPERATIVE EVALUATION :

Follow up period :6 months

Mayo wrist score : 90

Pre – op X-ray

Post Op X-ray



5 months follow up Xrays

Clinical Photos

CASE ILLUSTRATION - V

PRE OPERATIVE EVALUATION:

Name: Ashokdas

Age/ Sex: 43/M

IP No: 77053

Mode of injury:Self fall

Time from injury to admission: 3 days

Co-morbid illness: Hypertension

Associated injuries:-

Muller's classification and side: B3, left side

SURGICAL EVALUATION:

Time delay from injury to surgery :5 days

Time delay from admission to surgery :3 days

Position :supine

Anaesthesia :RA

Radius approach : Volar Henry

Type of Radius fixation :Volar LCP

POST OPERATIVE EVALUATION :

Follow up period :6 months

Mayo wrist score : 95

Pre-op

Post-op

Intra-op picture

Function Demonstration Day 1 Post-op

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PROFORMA

PRE OPERATIVE EVALUATION:

Name:

Age/ Sex:

IP No:

Mode of injury:

Time from injury to admission:

Co-morbid illness:

Associated injuries:

Muller's classification:

Radiological evaluation on presentation:

Palmar tilt

Radial inclination

Radial height

Deformity

Articular step

CT finding:

SURGICAL EVALUATION:

Time from injury to surgery:

Time from admission to surgery:

Position:

Anaesthesia:

Approach:

Radius:

Ulna:

Type of fixation:

Radius:

Ulna:

Post op immobilization (if any):

POST OPERATIVE EVALUATION:

Follow up period:

Wound status/ Infection:

Wrist pain:

Distal neurovascular status:

Union:

Time to union:

Wrist range of motion:

Radiological evaluation:

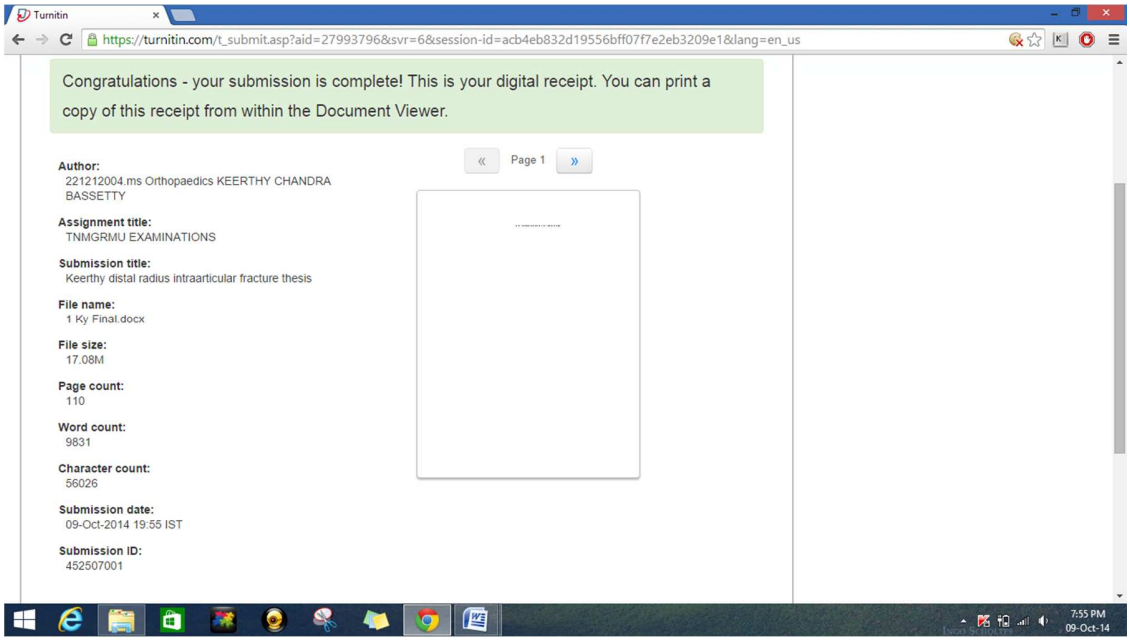
Palma tilt:

Radial inclination:

Radial height:

Deformity:

Return to employment: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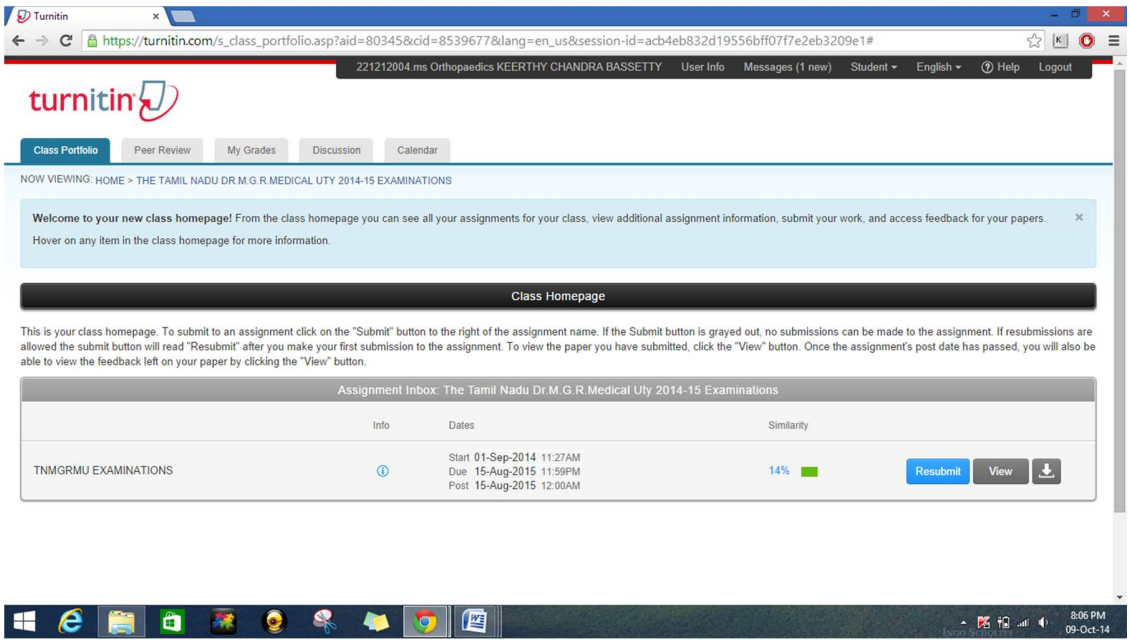
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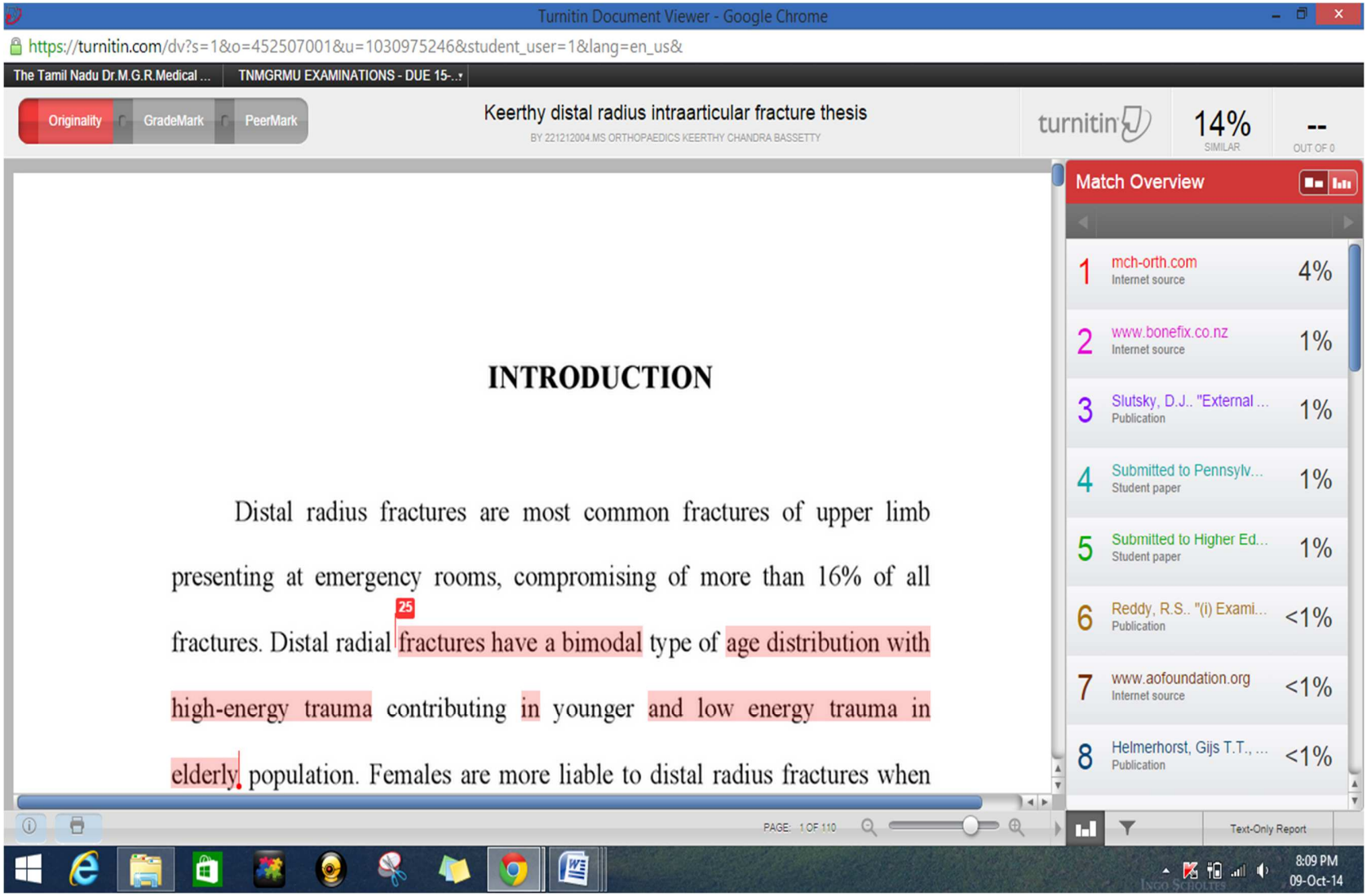
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Keerthy distal radius intraarticular fracture thesis
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INTRODUCTION
Distal radius fractures are most common fractures of upper limb presenting at emergency rooms, compromising of more than 16% of all fractures. Distal radial fractures have a bimodal type of age distribution with high-energy trauma contributing in younger and low energy trauma in elderly population. Females are more liable to distal radius fractures when
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INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI-3

EC Reg No.ECR/270/Inst./TN/2013
Telephone No : 044 25305301
Fax : 044 25363970

CERTIFICATE OF APPROVAL

To
Dr. Keerthy Chandra Bassetty,
Post Graduate in MS Orthopaedics,
Institute of Orthopaedics & Traumatology,
Madras Medical College, Chennai-3.

Dear **Dr. Keerthy Chandra Bassetty,**

The Institutional Ethics Committee of Madras Medical College, reviewed and discussed your application for approval of the proposal entitled **"Comparative study on the analysis of functional outcome in distal radius articular fractures treated by closed reduction through Bridging external fixator augmented with K-wires and Volar-locking plate."** No.07122013

The following members of Ethics Committee were present in the meeting held on 11.12.2013 conducted at Madras Medical College, Chennai-3.

1. Dr. G. Sivakumar, MS FICS FAIS	-- Chairperson
2. Prof. B. Kalaiselvi, MD Vice Principal, MMC, Ch-3	-- Member Secretary
3. Prof. Ramadevi, Director i/c, Instt. of Biochemistry, Chennai.	-- Member
4. Prof. P. Karkuzhali, MD for Dr. V. Ramamoorthy Prof. Instt. of Pathology, MMC, Ch-3	-- Member
5. Thiru. S. Govindasamy, BABL	-- Lawyer
6. Tmt. Arnold Saulina, MA MSW	-- Social Scientist

We approve the proposal to be conducted in its presented form.

Sd/Chairman & Other Members

The Institutional Ethics Committee expects to be informed about the progress of the study, and SAE occurring in the course of the study, any changes in the protocol and patients information / informed consent and asks to be provided a copy of the final report.

20/12/13

Member Secretary, Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

LIST OF ABBREVIATIONS USED

DRUJ Distal radio-ulnar junction

TFCC Triangular fibro-cartilage complex

BE Below – elbow

LCP Locking compression plate

FOOSH Fall on outstretched hand

ORIF Open reduction and internal fixation

PATIENT INFORMATION SHEET

TITLE OF THE STUDY: **Comparative study on the analysis of functional outcome in distal radius articular fractures treated by closed reduction through Bridging-Articulated external fixator augmented with K-wires and Volar-locking plating.**

We are conducting a study on "Comparative study on the analysis of functional outcome in distal radius articular fractures treated by closed reduction through Bridging-Articulated external fixator augmented with K-wires and Volar-locking plating" among patients admitted in the Institute of Orthopaedics & Traumatology, Rajiv Gandhi Government General Hospital, Chennai.

The purpose of this study is to compare the functional outcome in distal radius articular fractures treated by closed reduction through Bridging-Articulated external fixator augmented with K-wires and Volar-locking plating.

We are selecting certain cases based on radiographic pattern of distal radius fracture and if you are found eligible, we perform surgical procedure for the fractured limb by bridging-articulated external fixator with K-wiretechnique or Volar-locking plates or if you are all already operated for the fracture by the above mentioned technique we willevaluate the outcome of surgery, which in any way do not affect your final report or management.

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.

The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of Investigator Signature of Participant

Date :

PATIENT CONSENT FORM

Study Detail	:	COMPARATIVE STUDY ON THE ANALYSIS OF FUNCTIONAL OUTCOME IN DISTAL RADIUS ARTICULAR FRACTURES TREATED BY CLOSED REDUCTION THROUGH BRIDGING-ARTICULATED EXTERNAL FIXATOR AUGMENTED WITH K-WIRES AND VOLAR-LOCKING PLATES
Study Centre	:	Rajiv Gandhi Government General Hospital, Chennai.
Patient's Name	:	
Patient's Age	:	
Identification Number	:	

Patient may check (√) these boxes

a) I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask question and all my questions and doubts have been answered to my complete satisfaction. ❑

b) I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected. ❑

c) I understand that sponsor of the clinical study, others working on the sponsor's behalf, the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw from the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ❑

d) I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well being or any unexpected or unusual symptoms. ❑

e) I hereby consent to participate in this study. ❑

f) I hereby give permission to undergo detailed clinical examination, Radiographs ,blood investigations and surgical procedure as required. ❑

Signature/thumb impression

Signature of Investigator:

Study Investigator's Name: **Dr. KEERTHY CHANDRA BASSETTY**

Patient's Name and Address:

MASTER CHART FOR DISTAL RADIUS INTRAARTICULAR FRACTURES																
SR NO	**NAME**	**AGE/SEX/IP NO**	**A.O.TYPE**	**TREATMENT**	**DURATION**			**FUNCTIONAL OUTCOME**		**RADIOLOGICAL OUTCOME**				**MAYO SCORE**	**RESULT**	**COMPLIC**
					TO SURGERY (DAYS)	**OF FIXATION (MONTHS)**	**FOLLOWUP (MONTHS)**	**PALMAR/ DORSI FLEXION**	**SUPINATION/ PRONATION**	**VOLAR TILT**	**RADIAL HEIGHT**	**RADIAL INCLINATION**	**ARTHRITIS**			
1	SIVARAM	35/M 7813	B2	EX+K	1	3.5	6	80/70	80/70	11	11	23	NIL	90	E	NIL
2	MURUGAN	46/M 29176	B2	EX+K	3	3	8	80/70	70/60	3	8	15	NIL	95	G	PIN LOOSENING
3	RATHI	55/F 47942	C2	EX+K	1	4	6	40/30	20/30	3	5	10	YES	45	P	STIFFNESS INFECTION
4	MUNUSAMY	70/M 64323	C3	EX+K	15	3.5	7	30/30	20/10	-5	4	10	YES	60	P	MALUNION STIFFNESS
5	MOHAN	18/M 64232	C3	EX+K	1	4	5	70/50	50/30	-3	5	20	YES	45	P	MALUNION
6	DEVADOSS	70/M 67543	C1	EX+F	1	3	5	60/60	50/40	6	8	18	NIL	85	G	DELAYED UNION
7	MUNUSAMI	70/M 68564	C2	EX+K	15	3.5	5	60/40	45/30	0	0	6	NIL	70	F	PINSITE INFECTION& L
8	MANI	38/M 2341	C1	EX+K	1	3	6	65/50	80/80	8	8	16	NIL	80	G	NIL

SRNO	NAME	AGE/SEX/IP NO	A.O.TYPE	TREATMENT	DURATION			FUNCTIONAL OUTCOME		RADIOLOGICAL OUTCOME				MAYO SCORE	RESULT	COMPLIC
					TO SURGERY (DAYS)	OF FIXATION (MONTHS)	FOLLOWUP (MONTHS)	PALMAR/ DORSI FLEXION	SUPINATION/ PRONATION	VOLAR TILT	RADIAL HEIGHT	RADIAL INCLINATION	ARTHRITIS			
9	MANI	48/M 64217	C3	EX+F	14	3	5	50/40	40/30	-3	-2	10	YES	70	F	Pin Infection and Loosening
10	RAMANI	40/F 9178	B2	EX+F	3	3	4	70/60	60/40	3	6	18	NIL	85	G	NIL
11	SITAMMA	58/F 98654	C2	EX+F	1	3	4	70/60	70/50	2	2	10	NIL	80	F	NIL
12	MURUGAN	32/M 29176	B2	VLCP	1	17		80/70	70/60	5	10	21	NIL	95	E	NIL
13	RAJARAM	29/M 17183	C3	VLCP	28	8m		40/30	30/20	5	5	15	NIL	80	G	MALUNION INFECTION
14	ASHOKDAS	43/M 63813	B3	VLCP	5days	6m		60/80	90/90	12	13	24	NIL	95	E	NIL
15	HEMASAI	19/M 26387	B3	VLCP	3	8m		80/90	60/50	11	10	20	NIL	75	G	INFECTION
16	KANTHASAMY	70/M 64917	C1	VLCP	17	9m		60/70	45/50	10	10	15	YES	85	E	STIFFNESS
17	RAMACHANDRAN	47/M 78825	C1	VLCP	2	18m		60/60	50/40	10	10	20	NIL	95	E	NIL

SRNO	NAME	AGE/SEX	A.O.TYPE	TREATMENT	DURATION			FUNCTIONAL OUTCOME		RADIOLOGICAL OUTCOME				MAYO SCORE	RESULT	COMPLIC
					TO SURGERY (DAYS)	OF FIXATION (MONTHS)	FOLLOWUP (MONTHS)	PALMAR/ DORSI FLEXION	SUPINATION/ PRONATION	VOLAR TILT	RADIAL HEIGHT	RADIAL INCLINATION	ARTHRITIS			
18	VEERARAGHAVAN	55/M 85624	B2	VLCP	4	18		80/70	90/80	5	12	20	NIL	85	E	NIL
19	MEENAKSHI	60/F 91457	B2	VLCP	6	2y		80/80	90/60	3	10	18	NIL	90	G	STIFFNESS
20	KANDASAMY	60/M65718	B2	VLCP	4	12m		70/70	80/60	9	10	22	NIL	85	G	NIL
21	SIVAKUMAR	28/M23738	B2	VLCP	1	17m		80/70	70/60	5	10	11	NIL	75	G	PROMINENT IMPLANT
22	KANAMMAL	68/F 73245	B3	VLCP	5	17m		70/70	60/50	5	8	5	NIL	70	F	NIL
23	KAMALA	41/F76543	B2	EX	2	3	5m	80/60	70/40	3	5	12	NIL	90	F	NIL
24	YALIN	52/M 76543	C1	EX+F	1	3.5	6	90/70	80/70	4	4	10	NIL	65	F	NIL
25	ASHWIN	22/M10306	B1	EX	1	3	3	90/80	80/80	9	9	20	NIL	95	E	NIL
26	SHANTHI	55/F 98551	B3	EX+F	1	3	6	70/50	50/40	2	1	5	NIL	75	G	NIL
27	GOVINDAAMMAL	45/F 12324	C2	VLCP	3	9		80/70	70/50	8	9	12	NIL	85	G	NIL