"EVALUATION OF MANAGEMENT OF FRACTURE OF DISTAL END OF RADIUS IN ADULTS TREATED BY OPEN REDUCTION AND INTERNAL FIXATION BY PLATE AND SCREWS"

By

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DR. SHUSHRUT B BHAVI.

LIST OF ABBREVIATIONS

FDS	Flexor digitorum superficialis
TFCC	Triangular fibro cartilage complex
AO	Arbeitsgemainschaft fur Osteosynthesefragen
RT	Right
LT	Left
RTA	Road traffic accident
FOOH	Fall on outstretched hand
FFH	Fall from height
D.Injury	Direct Injury

ABSTRACT

BACKGROUND AND OBJECTIVE:

Fracture of the distal radius is one of the most common skeletal injuries treated by orthopaedic surgeons.

Restoration of radial length, radial tilt angle and congruity of articular surface is important for good functional result. Recognition of fracture patterns and fixation of fracture to secure and maintain reduction is the key for successful management of more complex fractures of distal radius.

Devices like buttress plates allow improved fracture fixation without leading to soft tissue and vascular complications. They have been shown to provide excellent stability for an unstable fracture with either dorsal or volar metaphyseal comminution.

The objective of the study was to evaluate the functional outcome of fracture of distal end of radius treated by open reduction and internal fixation by plate and screws using Criteria of Gartland and Werley Point System.

METHODS:

Thirty two patients with fracture of distal end radius were treated by open reduction and internal fixation by buttress plate and screws in Shri B.M.Patil medical college, B.L.D.E. University Bijapur, between October 2010 to April 2012.

RESULTS:

The study included 32 patients, 17 male and 15 females aged from 21 to 69 years with mean of 39.37 years. The average duration of follow-up was 7 months ranged from 6-10 months. Using the Demerit scoring system of Gartland and Werley, we had 18.7% excellent results, 46.8% good results, 18.7% fair results and 15.6% poor result. As per our results, excellent to good results were found in 65.6% of patients.

CONCLUSION:

Open reduction and internal fixation by buttress plate and screws can be an alternative to other procedures in treating the comminuted intra-articular fracture of distal end radius. Excellent to good results are produced by using buttress plate for fixation of distal radius fractures.

KEY WORDS:

Distal Radius Fracture, Open Reduction Internal Fixation, Buttress Plate.

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INTRODUCTION

INTRODUCTION

Fracture of the distal radius is one of the most common skeletal injury treated by orthopaedic surgeons. These injuries account for approximately one sixth of all fractures treated in emergency room[1].

Fractures of the distal end of the radius continue to pose a therapeutic challenge. Some of these fractures are caused by high energy trauma, resulting in intra-articular involvement and comminution. Treatment of such injuries is difficult. These fractures often are unstable, are difficult to reduce anatomically and are associated with complications of post-traumatic osteoarthrosis after intra-articular fracture of the distal end of the radius.

Fractures of the distal radius have been associated with colorful history since its first description by Ponteau in 1783 and later by Abraham Colle's in 1814[2].

Restoration of radial length (distance from radial styloid process to the distal end of ulna), radial tilt angle and congruity of articular surface is important for good functional result[3]. Failure to achieve and maintain near anatomic reduction can lead to degenerative arthritis, distal radio-ulnar and metacarpal instability and ulnar impaction syndrome with resultant pain, decreased mobility, strength and function[4].

Two important changes since the days of colle's are (a) increase in incidence of high energy vehicular trauma. (b) Greater demand for perfection by the patient. These factor change the mode of treatment.

Recognition of fracture patterns and fixation of fracture securely and to maintain reduction is the key for successful management of more complex fractures of distal radius.

Number of classification system has evolved taking into consideration the fracture patterns, degree of communition, radial shortening and displacement, dorsopalmar displacement, angulations and soft tissue involvement. Several classification have evolved that recognizes some of these variables, however no classification scheme successfully incorporates all the attributes of an individual injury. This places burden on the surgeon to evaluate each fracture individually.

Recent studies have emphasized that better methods of identifying and classifying distal radial fracture may direct the treating surgeon to alter the treatment and to adopt open reduction of these fractures in the proper circumstances[5].

Restoration of wrist function is the primary goal in the treatment of unstable distal Radius fractures. It is well accepted that the restoration of disrupted radial anatomy, maintenance of accurate and stable reduction, and early hand mobilization are required for good functional results in unstable distal Radius fractures. Open reduction and internal fixation is indicated to address the unstable distal Radius fractures and those with articular incongruity that cannot be anatomically reduced and maintained through external manipulation and ligamentotaxis, provided sufficient bone stock is present to permit early range of motion[6].

Since loss of reduction with subluxation of the carpus is so common, frequently used is a small buttress plate, as described by Ellis, as fixation for volar marginal fractures[7].

The best method of obtaining and maintaining an accurate restoration of articular anatomy, however remain a topic of controversy. Recognition of patterns that are inherently unstable and therefore necessitate additional form of fixation to secure and maintain reduction and prevents late collapse is the key for successful management of more complex fractures of distal radius.

Many things are subject to trend and fashion, and the treatment of distal radial fractures is no exception. Pins and plasters gave way to external fixation, and now internal fixation has begun to surpass all other treatment modalities[8].

The purpose of this study was to evaluate the functional outcome of surgical management of distal radial fractures in adults using Open Reduction and Internal Fixation with buttress plate and screws.

OBJECTIVES

OBJECTIVES OF THE STUDY

- To study incidence, mechanism of injury and classification of fractures of the distal end of radius.
- To make a prospective study of 32 adult cases of fractures of the distal end radius managed by open reduction and internal fixation by buttress plate and screws.
- To evaluate the functional outcome of fracture of distal end of radius treated by open reduction and internal fixation by buttress plate and screws using demerit-point system of Gartland and Werley[9].

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Fractures of the distal radius have been discussed in Orthopaedic literature for over 200 years[10]. The fracture patterns were described even before the advent of radiography. Although Ponteau in 1983, a French surgeon may have described this fracture pattern earlier, Abraham Colles is generally credited with description of the most common fracture pattern affecting the distal end radius. Colles fracture refers only to extra-articular fractures with dorsal displacement of the distal fragment. The other fracture patterns of the distal radius were described by Smith (a pattern of volar displacement of the distal fracture occurring 0.5 to 1 inch proximal to the articular surface).

Distal radial fractures have a bimodal age distribution, consisting of a younger group who sustains relatively high-energy trauma and an elderly group who sustains both high-energy injuries and insufficiency fractures[11].

Unstable bending fractures of the radial metaphysis are ideally suited for open reduction and internal fixation. Internal fixation of metaphyseal bending fractures has become increasingly popular due primarily to (a) directly control and maintain physiologic palmar tilt and (b) avoid bridging the radio carpal joint. The distal fragment typically has sufficient size and integrity to provide adequate purchase and may be approached from either a dorsal or a volar approach. Palmar plating is preferred, as the screws directly buttress against collapse and loss of palmar tilt. With smaller and more distal fragments, a dorsal plate has to be positioned distally on the dorsum of the Radius making extensor tendon injury more likely[12].

In 1929, Bholer published his original technique of Transfixation with skeletal pins and incorporation in plaster cast to maintain the reduction of fracture; the so called "pin and plaster method" and showed significantly better results than the century old method[13]. The basic principle was to provide fixed traction which prevents shortening of the radius at the fracture site.

Anderson and O'Neil were the first to use external fixation in the treatment of distal radial fracture in Seattle during world war by a principle known as ligamentotaxis[14].

In the early 1950s, James Ellis from England began using a specially designed T plate to buttress the small marginal fragment in Volar Barton's fractures. Ellis in 1965 was one of the earliest to recommend open reduction and internal fixation of the unstable Smith's fracture and of volar Barton's fracture[15].

John K.Bradway et al (1989) retrospectively reviewed the results in 16 patients with fractures of the distal radius treated by open reduction and internal fixation and concluded that open reduction and internal fixation is the treatment of choice for displaced, comminuted intra-articular fractures of distal radius when alignment of the articular surface cannot be obtained by closed means and anatomical restoration of the articular surface is required to prevent the sequela of post-traumatic arthritis[16].

Fitoussi F, et al (1997) in their study of 34 patients with intra-articular fractures of the distal radius treated with open reduction and internal fixation with buttress plate and screws, concluded that the potential for restoration of normal alignment and stability of fixation are the main advantages of internal fixation with plates[17].

Kenneth Swan Jr (2003) reviewed various plating options for distal radial fractures and stated that volar intra-articular lip fractures (Barton fractures) are best treated with a volar buttress plate[18]. Dorsal fixation with one plate frequently causes extensor tendon irritation or rupture. Volar plating for dorsal fractures is a relatively new method that has gained support through good results with decreased tendon irritation.

Cooney and **Berger** in 1993 suggested a more aggressive approach of open reduction, internal and external fixation and autogenous bone grafting in most high energy distal radius intra articular fractures to achieve the treatment goals of anatomic joint surface reduction, restoration of radial length and correlation of dorsal malalignment[2].

David Ring, Karl Prommersberger and Jesse B. Jupiter (2005) conducted a study[19] where 25 patients with subgroup-C3.2 fractures that had been treated with combined dorsal and volar plate fixation were evaluated at an average of twenty-six months after the injury. An average of 54° of extension, 51° of flexion, 79° of pronation, and 74° of supination were achieved. A good or excellent functional result was achieved for twenty-four patients (96%) according to the rating system of Gartland and Werley and for ten patients (40%) according to the more stringent modified system of Green and O'Brien. They concluded that Combined dorsal and volar plate fixation of the distal part of the radius can achieve a stable mobile wrist in patients with very complex fractures.

Gruber G et al in 2006 retrospectively studied the report of 104 patients, operatively treated over a period of 2 years with a mean follow up time of 15.6 months. The results were evaluated according to score of Gartland and Werley. Excellent and

Good results were achieved in 98% patients. This study showed that palmar plating of unstable fractures of distal radius is safe and effective treatment modality[20].

Ruch and Papadonikolakis in 2006 studied results of 34 patients of distal radius fractures treated with open reduction and internal fixation of a multifragmentary intra articular distal radius fractures with either a non locking volar or dorsal plate, 20 patients with a dorsal plate and 14 patients with a volar plate. They concluded that Volar plating resulted in a significantly better Gartland and Werley score compared with dorsal plate[21].

Kamath et al in the year 2006 studied 30 patients treated with low profile stainless steel plates for fracture distal end radius. The functional outcome was evaluated by Gartland and Werley scoring system. 28 patients had good or excellent results. From this study they concluded that patients can expect to have 80% of their range of motion and strength after dorsal plating for distal radius fractures, with 93% of good to excellent functional outcome[22].

Simic et al in year 2006 studied sixty consecutive unstable fracture in 59 patients treated by open reduction and internal fixation using dorsal plating system. There were 29 type A, 14 type B and 8 type C fractures. The minimum follow-up period was 1 year; the mean follow-up period was 24 months. Clinical evaluation was performed and plain radiographs were assessed for maintenance of immediate post operative reduction and implant position. From this they concluded that treatment of distal radius fractures with a dorsal plating system is a safe and effective method that provides stable internal fixation and allows for full extensor tendon glide and full metacarpophalangeal joint motion[23].

Rozental and Blazar in year 2006 reviewed internal fixation using volar plates for dorsally displaced comminuted distal radius fractures. Outcomes were evaluated using Gartland and Werley scoring system in 41 patients with a mean age of 53 years. The average follow-up period was 17 months. From this they concluded that patients with unstable dorsally displaced fractures of distal radius treated with volar plate have good or excellent functional outcomes[24].

Gerald Gruber, Max Zacherl, Christian Giessauf, Mathias Glehr, Fioretine fuerst et al conducted study in 2010[25] in which 54 consecutive patients with intra articular distal radius fractures and a mean age of 63 years were managed with volar locked plate system. At the time of last follow up >90% of all patients had achieved good or excellent results according to the scoring system of Gartland and Werley.

ANATOMY

NORMAL ANATOMY

Anatomy of the distal radius[26]:

The distal end of radius, the widest part is a four sided in section. Its lateral surface is slightly rough, projecting distally as a pyramidal styloid process.

Inferiorly, is the smooth carpal articular surface, divided by a ridge into medial and lateral concave areas. Ulnar or medial area is quadrangular and articulates with lunate. The lateral concave area is triangular, with its apex on the styloid process. It articulates with scaphoid.

The ulnar surface or medial surface shows a notch for articulation with head of ulna. Above this is a triangular area enclosed by anterior and posterior ridges. The interosseous membrane is attached to the posterior ridge.

Anterior surface is a thick, prominent ridge, palpable even through overlying tendons, 2 cm proximal to the thenar eminence.

The posterior surface displays a prominent palpable dorsal tubercle of Lister, in line with the cleft between the index and middle fingers. Posterior interosseous nerve lies on posterior surface beneath extensor digitorum tendons.

The extensor retinaculum, a thickened deep fascia, is attached to the prominent ridge on the lateral side of the pronator hollow (i.e. on the anterior surface of radius) and sweeps obliquely across to the radius, making compartments for the extensor tendons. Four compartments lie on the lower end of radius, and fifth over radioulnar joint. The sixth compartment lies over the head of the ulna. This expanded lower end of radius (via the thenar eminence) takes the full thrust of a fall on the outstretched hand and may lead to the lower end of radius fracture.

ANATOMY OF WRIST JOINT[26]

The radiocarpal or wrist joint is a bi-axial joint, commonly classified as ellipsoid. The parts forming it are the distal end of the radius and lower surface of the articular disc above and the scaphoid, lunate and triquetral bones below. The articular surface of the radius and the lower surface of the articular disc form together a roughly elliptical, concave surface with its long axis transversely disposed. However, the radial surface is divided into two by a low ridge and therefore bears two concavities. A similar ridge is usually distinguishable between the medial concavity on the radius and the concave distal surface of the articular disc. The proximal articular surface of the scaphoid, lunate and triquetral bones form a fairly smooth convex surface, which is received into the proximal concavity. The line of the joint corresponds to a line, convex upwards, joining the styloid process of the radius to that of the ulna.

The articular capsule is lined by synovial membrane which is usually separate from that of the inferior radio-ulnar and intercarpal joints, but a protruding pre styloid recess, ventral to the articular disc, is present and ascends close to the styloid process. The recess is bound distally by a fibro cartilaginous meniscus, projecting from the ulnar collateral ligament between the tip of the ulnar styloid process and the triquetral.

The palmar radio carpal ligament, a broad membranous band is attached to the anterior margin of the distal end of radius and its styloid process, its fibers passing distomedially to the anterior surface of scaphoid, lunate and triquetral bones, some reaching the capitate.

The palmar ulnocarpal ligament is a rounded fasciculus which runs from the base of the styloid process of the ulna and the anterior margin of the triangular articular disc of the distal radio-ulnar joint to the lunate and triquetral bones. The palmar ligaments of the wrist are perforated by apertures for the passage of vessels and are in relation, in front, with the tendons of the flexor digitorum profundus and flexor pollicis longus.

The dorsal radiocarpal ligament, thinner and weaker than the palmar as attached, above to the posterior border of the distal end of the radius; its fibers are directed obliquely downwards and medially, and are fixed, below to the dorsal surfaces of the scaphoid, lunate and triquetral bones being continuous with those of the dorsal intercarpal ligaments. It is related behind, with the extensor tendons of the wrist and fingers, their synovial sheaths and the posterior interosseous nerve; in front, it is blended with the articular disc of the inferior radio-ulnar articulation.

The ulnar collateral ligament of the wrist joint is attached to the end of the styloid process of the ulna; it is divides into two fasciculi, one of which is fixed to the medial side of the triquetral, the other to the pisiform bone.

The radial collateral ligament of the wrist joint extends from the tip of the styloid process of the radius to the radial side of the scaphoid bone, some of its fibres being prolonged to the trapezium. It is in relation with the radial artery as it winds around the lateral side of the wirst separating the ligament from the tendons of abductor pollicis longus and extensor pollicis brevis. Both collateral ligaments are relatively poorly developed.

Blood supply:

Arteries supplying the joint are anterior interosseous, anterior and posterior carpal branches of radial and ulnar arteries, palmar and dorsal metacarpal recurrent branches of the deep palmar arch.

Anatomic Relations of Median nerve:

The median nerve emerges at the wrist from under the muscular belly of the flexor digitorum superficialis (FDS) and progresses to lie beneath the index finger and lateral to the middle tendons of the FDS. The artery of the median nerve, a branch of the anterior interosseous artery, lies directly on the median nerve and serves as a landmark of nerve orientation. The median nerve lies on the anterior aspect of the distal radius, with pronator quadratus between the nerve and the bone. Distally, the nerve lies near the radio carpal joint capsule, before entering beneath the flexor retinaculum. It then enters into the carpal tunnel, keeping the same relationship with the tendons and the synovial sheaths of the flexor tendons to divide into terminal branches as it emerges from the carpal tunnel. Its sheath is surrounded by a net of sympathetic fibers going to the hand.

The Ulnar Nerve:

In the distal radius fractures, the ulnar nerve is less exposed to injury than the median nerve. It is not directly on the fracture line and not involved in compression syndromes in the carpal tunnel, being outside in the Guyon’s canal. When distal radius fractures are associated with either ulnar fractures or dorsal or palmar dislocations, then the ulnar nerve injury is more common.

The Sensory Branch of the Radial Nerve:

The sensory portion of the radial nerve perforates the superficial aponeurosis behind the tendon of the brachioradialis and penetrates the wrist area before crossing this tendon. Just proximal to the distal end of radius, the radial sensory nerve divides into three terminal branches; lateral, middle and medial. It runs lateral to the radial artery and just superficial to the abductor pollicis longus and extensor pollicis brevis tendons.

A direct injury to the radial nerve is not uncommon at the time of distal radius fractures. In addition, it can be injured when reducing and stabilizing the fracture by pinning. Longitudinal incisions are necessary to carefully retract and preserve branches of the radial nerve. Percutaneous pinning should be avoided in these to prevent painful neuromas, which are difficult to cure.

RADIOCARPAL AND INTERCARPAL MOVEMENTS:

Movements of radiocarpal and intercarpal joints are considered as a common mechanism acted on by the same muscles. Active movements are flexion (palmar flexion) (range 60^0 – 65^0), extension (dorsiflexion) (range 70^0 – 75^0), adduction (ulnar deviation) (30^0 - 35^0), abduction (radial deviation) (range 20^0 – 25^0) and circumduction.

In carpal flexion, radiocarpal and midcarpal joints is involved, the range being greater at midcarpal joint and in extension, the reverse occurs with more movement at the radiocarpal joint. Hence the proximal surfaces extend further posteriorly on the lunate and scaphoid bones. These movements are limited chiefly by antagonistic muscles; therefore the range of flexion is perceptibly diminished when fingers are flexed, due to the increased tension in the extensors.

Adduction of the hand is greater than abduction due to the more proximal site of the ulnar styloid process. Most adduction occurs at the radiocarpal joint. The lunate bone articulates with both radius and articular disc when the hand is in mid position, but in adduction lunate passes off the disc to articulate solely with the radius. Much of the proximal articular surface of a scaphoid becomes subcapsular beneath the radial collateral ligament and forms a smooth convex palpable prominence in the floor of anatomical snuffbox.

Abduction occurs almost entirely at the midcarpal joint. On abduction capitate rotates around an anteroposterior axis so that its head passes medially and the hamate confirms to this. The distance between the lunate and the apex of hamate is increased. The scaphoid rotates around a transverse axis, its proximal articular surface is retreated from the capsule and is now in sole articulation with the radius. Movements are limited by antagonistic muscles and at extremes by the collateral carpal ligaments.

DISTAL RADIOULNAR JOINT

The distal radioulnar joint is a pivot or trochoid joint, in which the circular head of the ulnar articulates with the shallow sigmoid notch on the ulnar aspect of the distal radius. The radius rotates around ulna, but this movement is accompanied by translation, so that in supination, ulna is somewhat volar while in pronation it is more dorsal relative to the radius.

Ligamentous anatomy of distal radioulnar joint has been more clearly defined in recent years. Triangular fibro-cartilage was thought for many years to be key element in maintaining integrity and stability of the joint. Kauer[27] (1975) was the first to challenge this traditional concept, demonstrating that this cartilage is only part of an extensive fibrous system originating from the distal end of the radius and extending to base of the fifth metacarpal. His concepts have been supported and expanded upon by independent studies by Bowers, Palmer and Werner. The term triangular fibro cartilage complex (TFCC) was introduced by Palmer and Werner[28]. The TFCC incorporates the dorsal and volar radioulnar ligaments, the ulnar collateral ligaments, the meniscus homologue-articular disc, the sheath of extensor carpi ulnaris tendon and the ulnolunate and ulnotriquetral ligaments. The complex originates from the ulnar aspect of lunate fossa of radius and inserts into fovea at the base of ulnar styloid. It flows distally (joined by fibers arising from ulnar aspect of ulnar styloid, the collateral ligament), becomes thickened and inserts distally into lunate, triquetrum, hamate & base of fifth metacarpal.

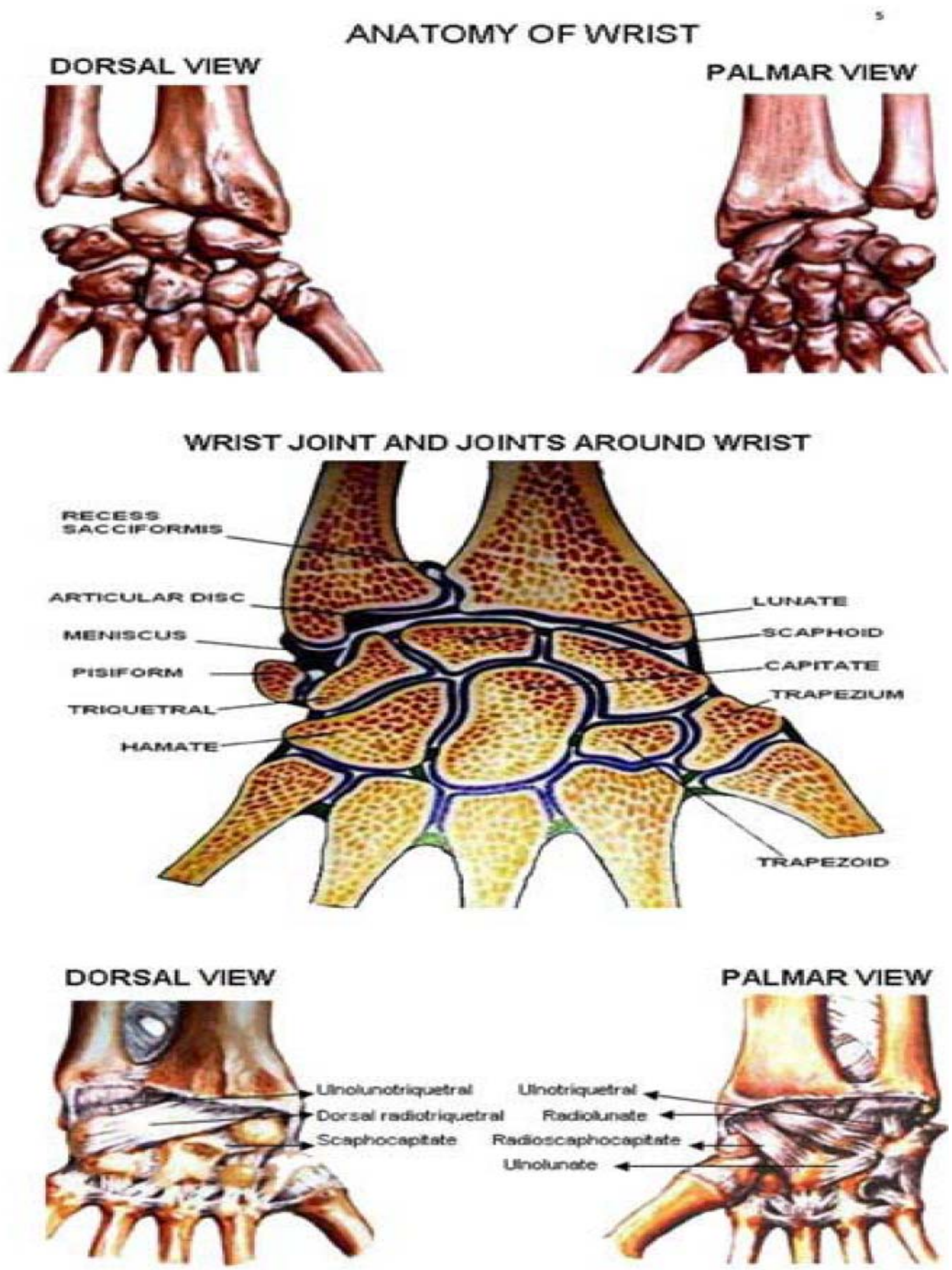
The portion of TFCC called the articular disc or triangular fibro cartilage arises from sigmoid notch of the radius and inserts into base of ulnar styloid. It is biconcave, being thicker at the periphery and thinner at center. Only the outer portion is vascular; the remainder is avascular, which suggest that tears in the central, avascular portion do not have potential to heal.

The functions of TFCC are to:

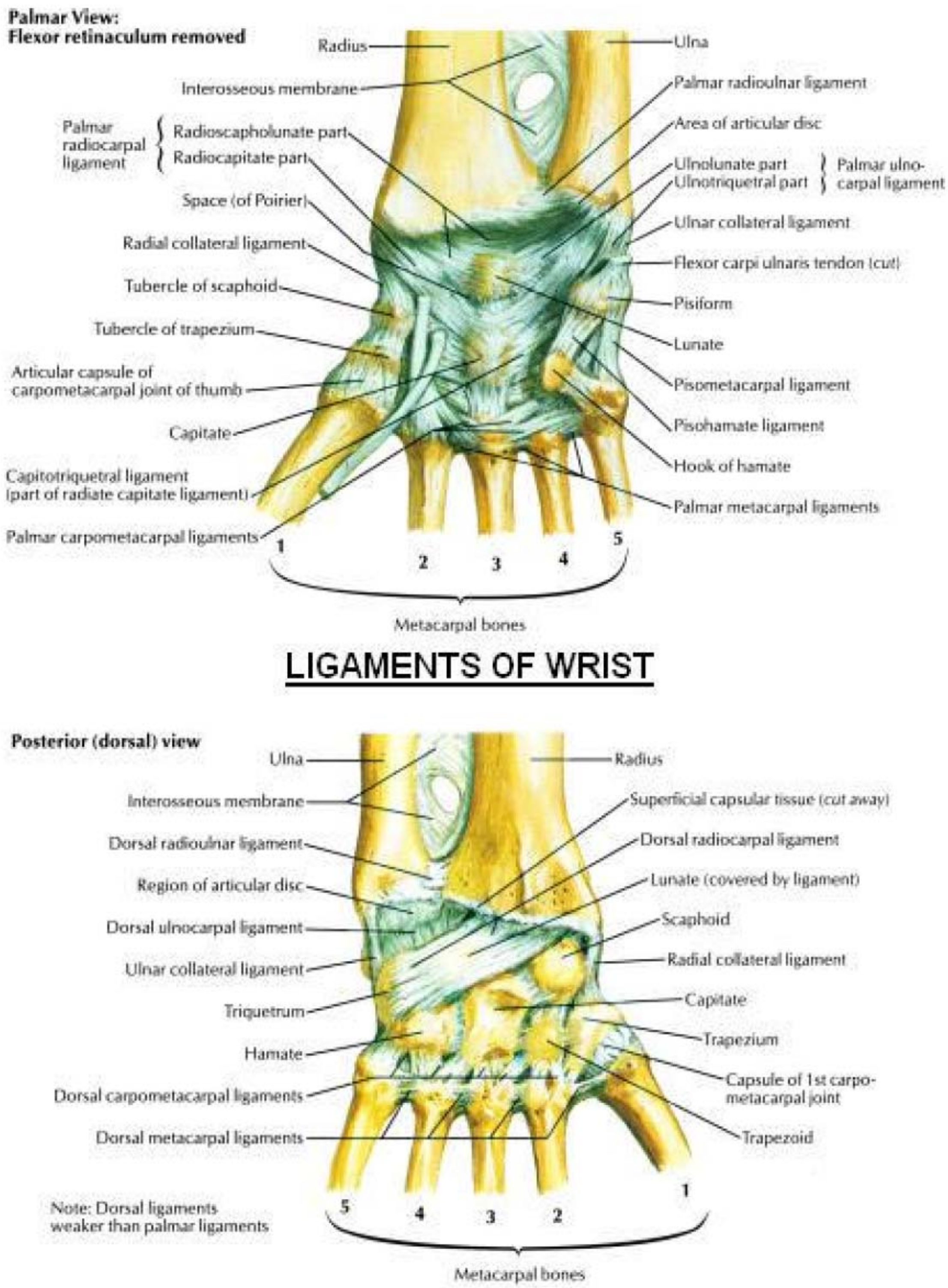
1) Provide a continuous gliding surface for flexion, extension and translation of carpus on forearm.
2) Impart stability to radioulnar joint to allow rotational movements of forearm.
3) Suspend the ulnar carpus from dorsal surface of radius.
4) Cushion the forces transmitted through the ulnocarpal axis.
5) Solidly connect the ulnar axis to volar carpus.

Complex disruption of radioulnar joint is a frequent accompaniment of distal radius fracture. This necessitates restoration of full length of radius in distal radius fracture.

ANATOMY OF WRIST:



LIGAMENTS OF WRIST:



MUSCLES:

1) **ANTERIOR ANTEBRACHIAL MUSCLES:**

A) Superficial flexor group (attached to humerus)

Name of Muscle	Origin	Insertion	Nerve Supply	Nerve Roots	Action
Pronator teres **a) Humeral head** **b) Ulnar head**	Medial epicondyle of humerus Medial border of coronoid process of ulna	Lateral aspect of shaft of radius	Median nerve	C6,C7	Pronation and flexion of forearm
Flexor carpi radialis	Medial epicondyle of humerus	Bases of second and third metacarpal bones	Median nerve	C6, C7	Flexes and abducts hand at wrist joint
Palmaris longus	Medial epicondyle of humerus	Flexor retinaculum and palmar aponeurosis	Median nerve	C7,C8	Flexes hand
Flexor carpi ulnaris **a) Humeral head** **b) Ulnar head**	Medial epicondyle of humerus Medial aspect of olecranon process and posterior border of ulna	Pisiform bone, hook of the hamate, Base of fifth metacarpal bone	Ulnar nerve	C8,T1	Flexes and adducts hand at wrist joint
Flexor digitorum superficialis **a) Humeroulnar head** **b) Radial head**	Medial epicondyle of humerus; medial border of coronid process of ulna Oblique line on anterior surface of shaft of radius	Middle phalanx of medial four fingers	Median nerve	C7, C8, T1.	Flexes middle phalanx of fingers and assists in flexing proximal phalanx and hand.

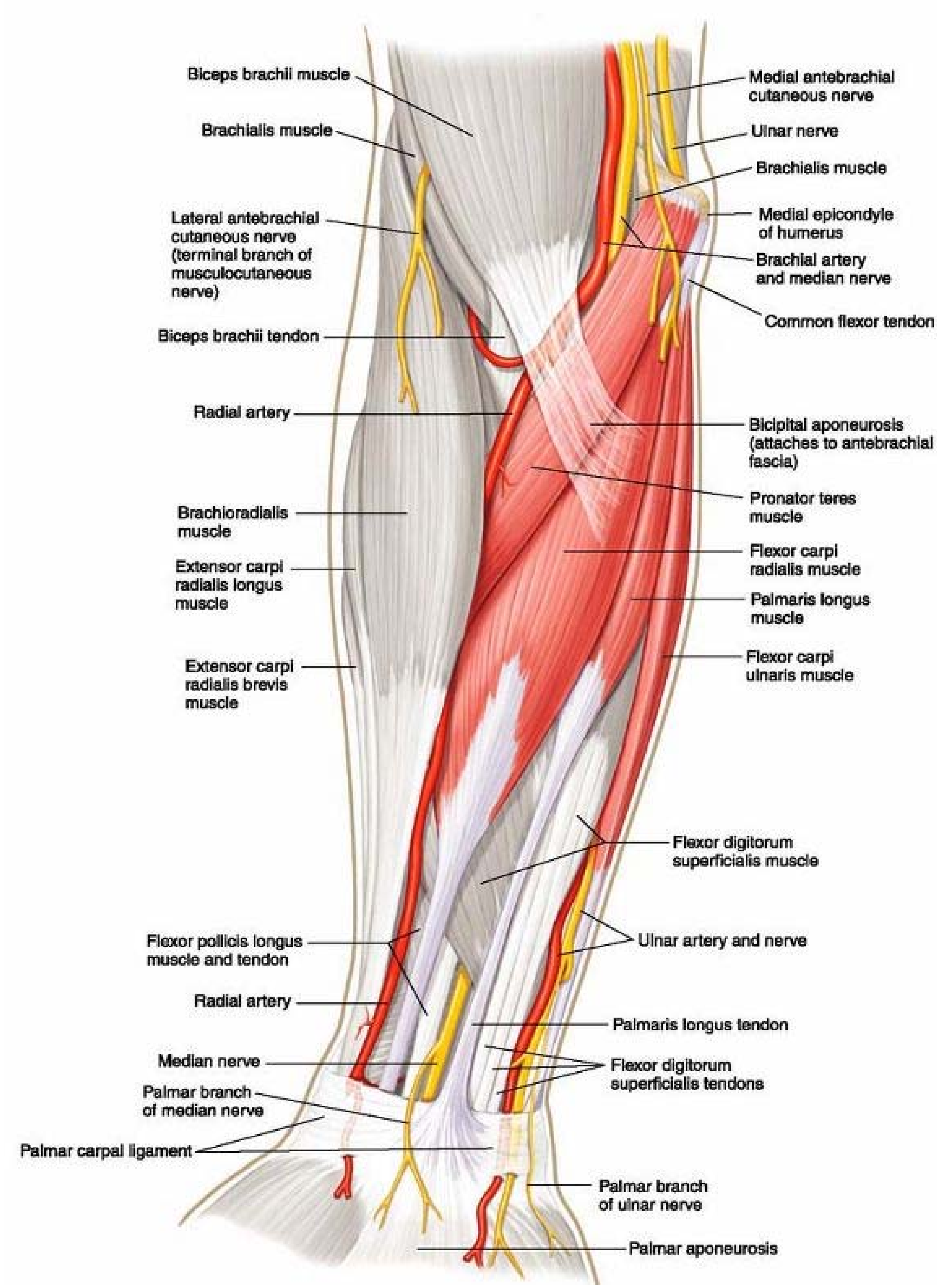
B) Deep flexor group (attached to radius and ulna)

Name of Muscle	Origin	Insertion	Nerve Supply	Nerve Roots	Action
Flexor pollicis longus	Anterior surface of shaft of radius	Distal phalanx of thumb	Anterior interosseous branch of median nerve	C8,T1	Flexes distal phalanx of thumb
Flexor digitorum profundus	Anteromedial surface of shaft of ulna	Distal phalanges of medial four fingers	Ulnar (medial half) and median (lateral half) nerves	C8,T1	Flexes distal phalanx of fingers; then assists in flexion of middle and proximal phalanx
Pronator quadratus	Anterior surface of shaft of ulna	Anterior surface of shaft of radius	Anterior interosseous branch of median nerve	C8,T1	Pronates foream.

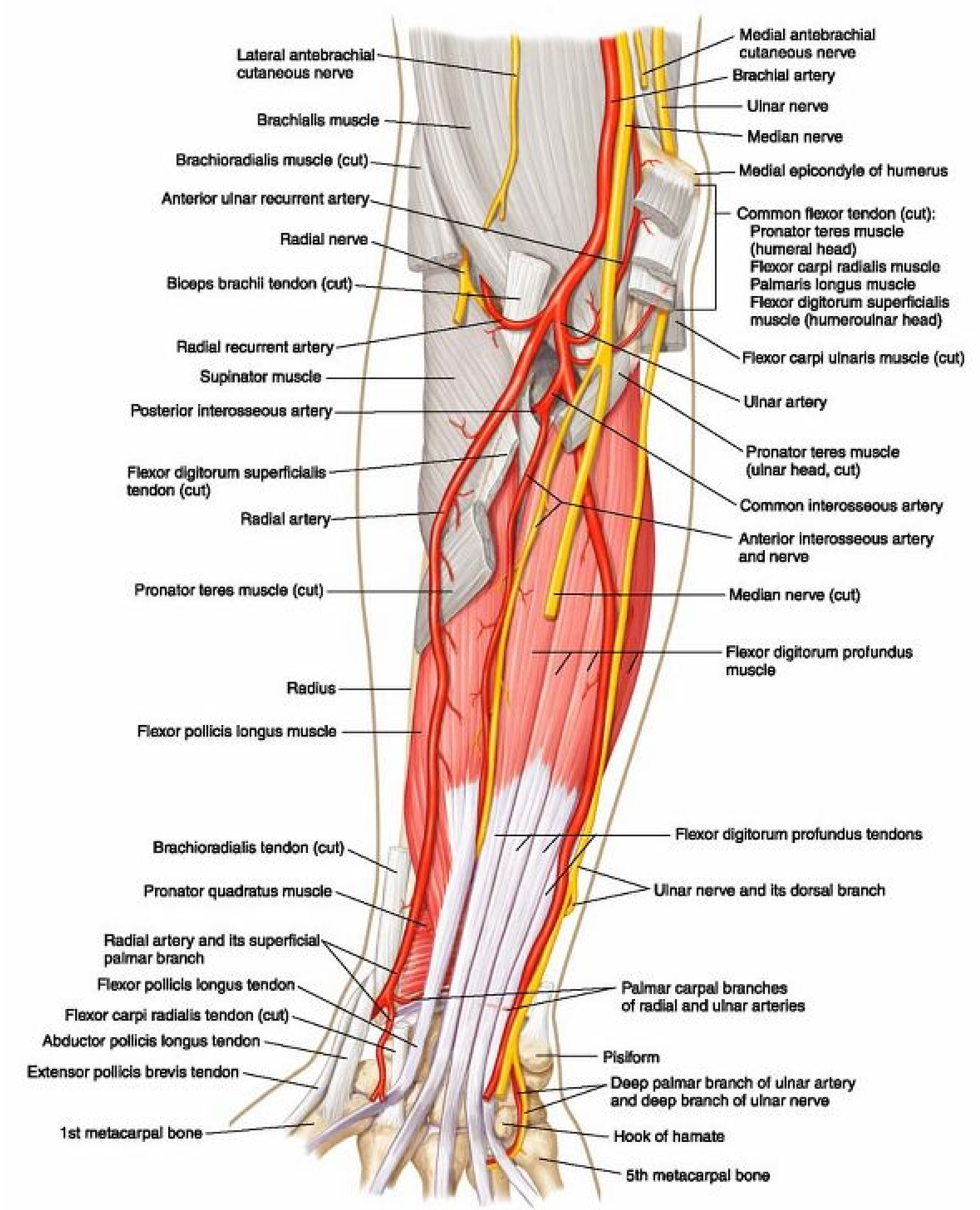
DEEP EXTENSOR GROUP (attached to radius and ulna)

Name of Muscle	Origin	Insertion	Nerve Supply	Nerve Roots	Action
Supinator	Lateral epicondyle of humerus, annular ligament of proximal radioulnar joint, and ulna	Neck and shaft of radius	Deep branch of radial nerve	C5, C6	Supination of forearm
Abductor pollicis longus	Posterior surface of shafts of radius and ulna	Base of first metacarpal bone	Deep branch of radial nerve	C7,C8	Abducts and extends thumb
Extensor pollicis brevis	Posterior surface of shaft of radius	Base of proximal phalanx of thumb	Deep branch of radial nerve	C7,C8	Extends metacarpophalangeal joints of thumb
Extensor pollicis longus	Posterior surface of shaft fo ulna	Base of distal phalanx of thumb	Deep branch of radial nerve	C7,C8	Extends distal phalanx of thumb
Extensor indicis	Posterior surface of shaft of ulna	Extensor expansion of index finger	Deep branch of radial nerve	C7,C8	Extends metacarpophalangeal joint of index finger.

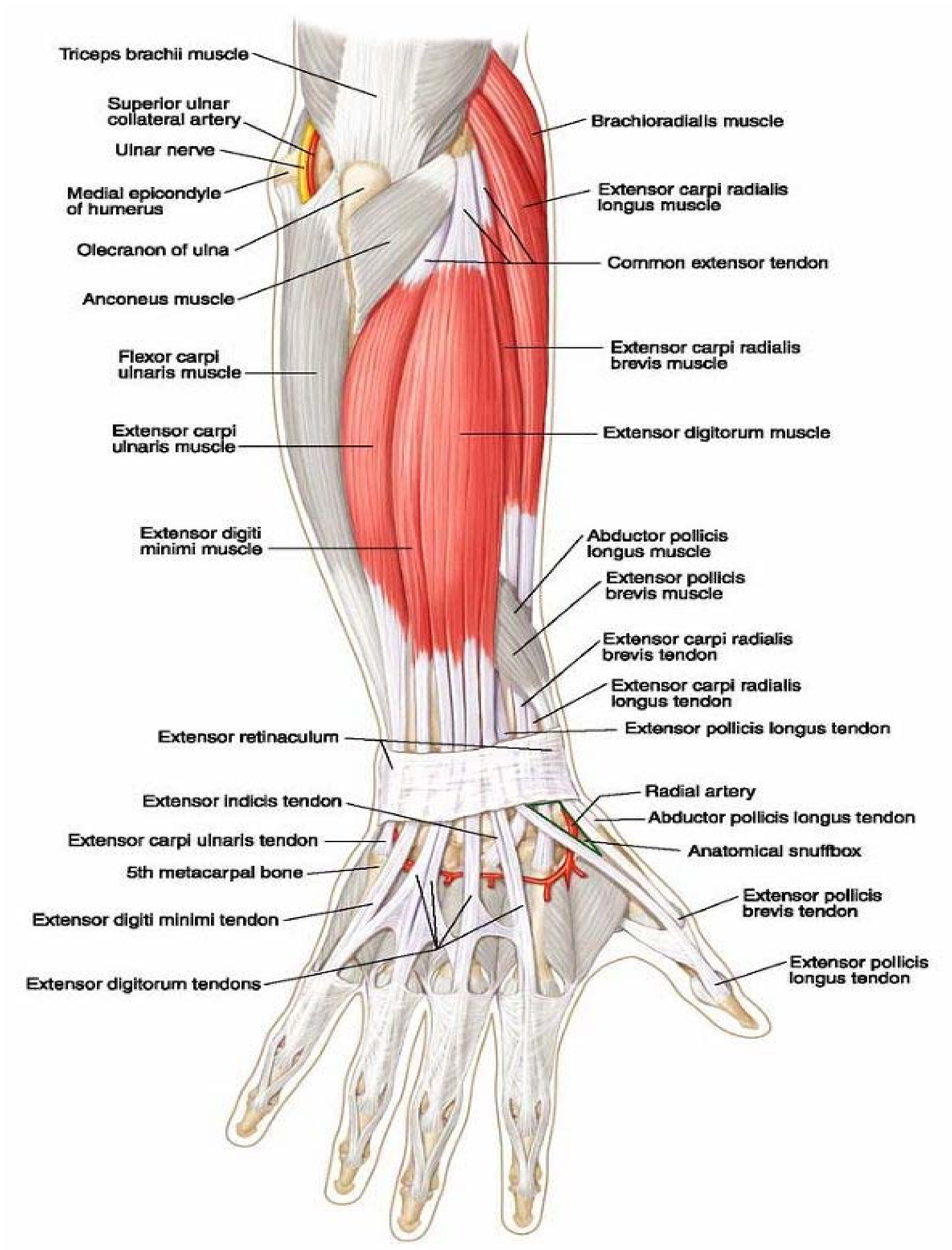
MUSCLES OF ANTERIOR FOREARM (SUPERFICIAL DISSECTION)



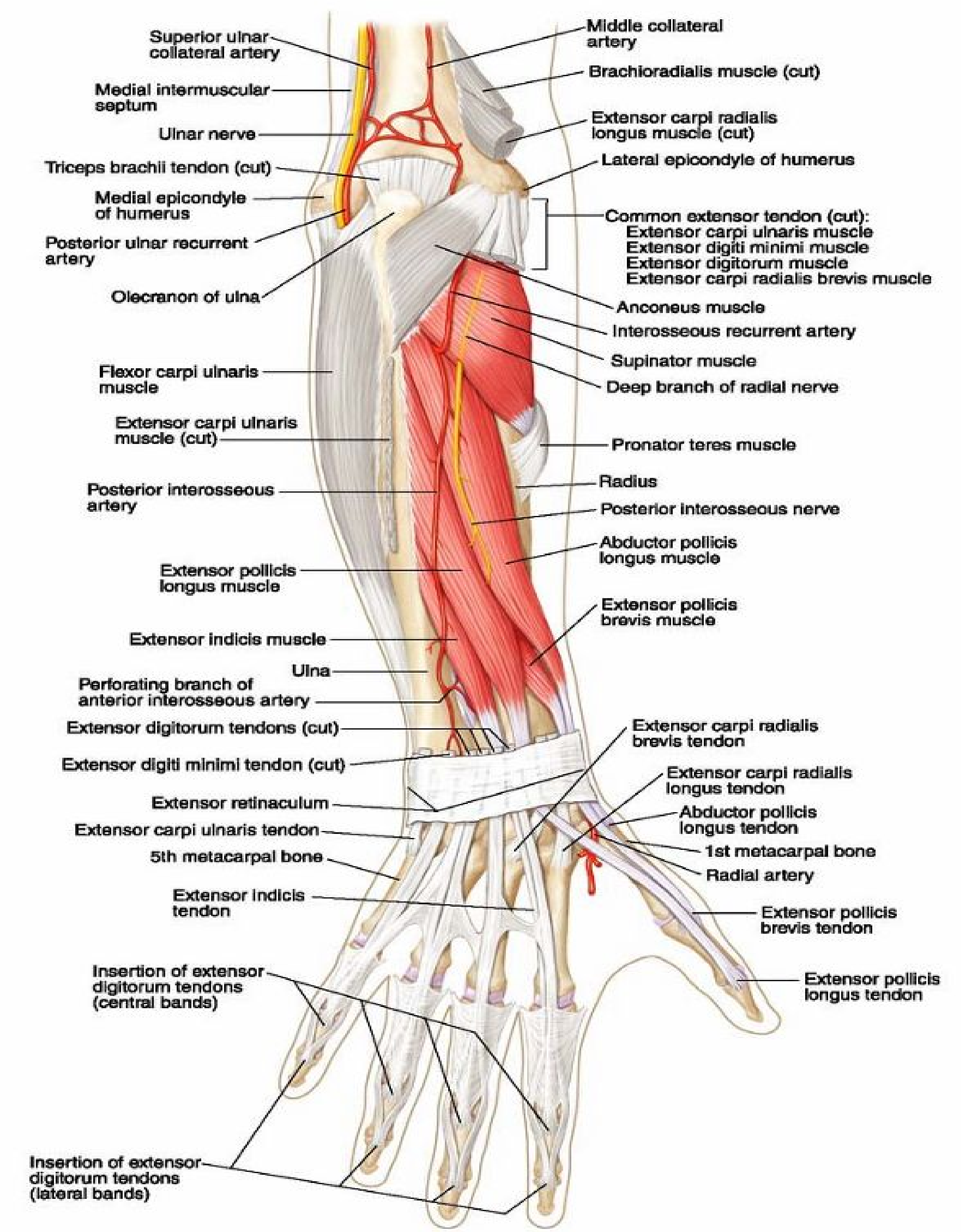
MUSCLES OF ANTERIOR FOREARM (DEEP DISSECTION)



MUSCLES OF POSTERIOR FOREARM (SUPERFICIAL DISSECTION)



MUSCLES OF POSTERIOR FOREARM (DEEP DISSECTION)



BIOMECHANICS OF WRIST

BIOMECHANICS OF WRIST

The distal radio-ulnar joint is a complex joint involved in pronation, supination and ulnar carpal motion and support. The ulnar head, in a rolling sliding motion moves from dorsal to volar rim of the sigmoid notch as the joint moves from pronation to supination. The triangular fibrocartilage is taut first dorsally and then volarly in the same sequence.

Wrist function is dependent on integrity and alignment of the radius with its carpal and ulnar articulations[29]. Radiocarpal and medial midcarpal complex are suggested to be in the form of a 'Link Joint' like a bicycle chain. This is stable only when under tension and 'On Center' with links in line; unless strengthened by a 'Stop' device it buckles under longitudinal compression, especially when 'Off Center'. But some advantages are inherent, since the range of movement at each unit is less than the total, articular surfaces can be flatter than in a single joint of the same total range and are better adapted to pressure. Further overlying tissues are less disturbed by squeezing at the extremes of movement.

The carpus is envisaged in four functional units:

1. Trapezium.
2. Scaphoid.
3. Hamate, Capitate & trapezoid.
4. Triquetrum & lunate.

In most manual positions, carpal bones are loosely packed and relatively mobile, they become a rigid block only in full extension (the closed packed position for radiocarpal and most carpal joints). Closed packing is achieved in two stages.

From flexion to extension, stages considered to occur are:

I. Initially the distal row (3) moves on proximal (2 & 4) until hand and forearm are in line; hamate, capitate, and trapezoid, and scaphoid coming into mutual close pack to form a rigid mass (i.e. 2 & 3).
II. Later this mass moves upon the triquetrum & lunate, which moves at the radiocarpal joint until full extension is reached, with close packing of the radiocarpal and most carpal joints (i.e. except articulation of pisiform and trapezium). In this position adopted only for special effort, very large forces can be transmitted through the articular structures. A similar position is often adopted to resist falls on outstretched hand, and commonly results in supination fracture or distal radius fracture.

Ulnar variance:

There is a considerable variation in the relative lengths of the two forearm bones as measured at the wrist. By convention an ulnar variance of 0 is one in which the distal cortical surface of the ulnar pole is level with the cortical surface of the most proximal aspect of lunate fossa on a perpendicular to the longitudinal axis of the forearm when the x-ray is taken with the wrist and forearm at neutral extension and deviation and with the x-ray tube perpendicular to the plane of the radiocarpal joint. A minus variant indicates an ulna shorter and a plus an ulna longer than the corresponding radius. Although most forearms are within 2 mm of a plus and 4 mm of a minus, pathological conditions are more common at the extremes. The importance of ulnar variance concerns the distribution of compressive load across the wrist joint. Studies conducted by Palmer and Werner showed that in ulnar neutral wrist that 80% radiocarpal and 20% ulnocarpal distribution was a good approximation, with the recession of ulna the load borne through the ulna rapidly diminished. Conversely the opposite happened with ulnar lengthening.

The component of force directed to the head of ulna is transmitted through the triangular fibro cartilage. The TFCC appears thinner in wrists with a positive variance and thicker with a negative variance and for these reasons the ulnar minus wrist does not transfer load as readily to the ulnar head. The consequence of this is that the forces across the lunate may abruptly change at the interface between radial articular surface and TFCC. Differential pressures between the lunate and triquetrum also change during radio-ulnar deviation, this undoubtedly has a bearing on several problems including kienbock's disease, scapholunate dissociation, lunotriquetral dissociation and TFCC disruptions. Two additional features that influence the transfer of stress are the piston like motion of the radius on the ulna that occurs with pronation - supination and that which occurs with dynamic loading with the former a small but distinct relative movement occurs longitudinally between the two bones such that the ulna appears to lengthen about one mm from the fully supinated to pronated position. Forceful grasping appears to cause the radius to translate proximally whereas ulnar deviaton appears to depress the ulna. The obliquity of radial articular surface in the coronal plane may also have a bearing on functions at the distal radio-ulnar joint. This is commonly measured as the angle between a line joining the radial styloid to the ulnar edge of the lunate fossa and the longitudinal axis of the forearm it average about 25^0.

Stability:

Stability is provided by the contour of the joints, the surrounding ligaments and the overlying tendons. The incisura of the sigmoid notch is shallow and provides a minimal constraint to subluxation of distal radio-ulnar joints. The dorsal and volar radio-ulnar ligaments at the perimeter of the TFCC provide the primary constraints to the distal radio-ulnar joint. In pronation the dorsal radio-ulnar ligament is under tension and in supinaton the volar radio-ulnar ligament is under tension. Paradoxically it is the volar radioulnar ligament that prevents dorsal subluxation of ulnar head if the dorsal radio-ulnar ligament is cut and vice versa. The dorsal and volar radio-ulnar ligaments provide only modest longitudinal stability allowing 5 mm of play between radius and ulnar. Avulsion of radio-ulnar ligaments from either the radial or ulnar origins results in increased mobility of the ulnar head on the radius which may be perceived by ballottement test such as 'piano key sign'. The distally anchored ulno carpal ligaments also provide some constraints to the ulnar head. When under tension the palmar ulno triquetral ligament helps depressed the head. The ligamentous continuation of the TFCC which includes the fibrous floor of the sixth dorsal compartment and the meniscal and styloid periosteal extension sometimes referred to as the ulnar collateral ligament also provides ulno carpal stability. The dorsal retinaculum which is important to radiocarpal stability bypasses the ulnar head distally.

PATHOANATOMY

PATHOANATOMY

The type of fracture produced depends upon the position of the wrist at the time of injury the magnitude and direction of force and the physical properties of the Bone.

The distal radius fracture is caused by a fall on the outstretched hand. When a person falls on to the outstretched hand, the prominent thenar eminence takes the brunt of force. The fractures of the lower end of radius occurs while the triangular fibrocartilage is still intact, therefore there is a rotary element with center of rotation at the ulnar styloid; the lower end of the radius rotating into supination. If the force continues, the ulnar styloid is avulsed. Therefore there can be a wide variety of displacements of lower end of radius, but basically six positions are recognized. These are impaction, lateral displacement, lateral rotation, dorsal displacement, dorsal rotation and supination. The brachioradialis is the only muscle inserted to the distal radius and acts as a deforming force[29].

When a person falls on an out stretched hand, there is transmission of 80% axial load to distal radius and 20% axial load to distal ulna / TFCC. 90% of wrist injuries are caused by stress loading with wrist in dorsiflexion (fall onto outstretched). Wrist in 40^0 – 90^0 dorsiflexion produces distal radius fracture. Wrist in > 90^0 dorsiflexion produces carpal injury. The palmar tensile force fails first then the dorsal compression force produces comminution of dorsal cortex.

Comminution of distal radial metaphysis is defined as ‘involvement of >50% of the diameter of metaphysis as seen on any radigraph, comminution of at least two cortices of metaphysis, or >2mm of shortening of the radius[29].

Majority of the distal radial fractures are extra-articular, 60% associated with ulnar styloid fracture, 50% associated with TFCC tears, 12% associated with carpal fractures. Distal radius fractures that have a shear or compression component produce intra-articular fractures that are considerably more unstable than bending metaphyseal extra-articular fractures. Concomitant ligamentous injuries are therefore to be expected[30]. In elderly extra-articular metaphyseal fractures and in younger comminuted, intra-articular fractures are common.

The amount of force necessary to produce distal radius fracture varies in dorsiflexed wrist from 105-440 kg with mean of 195 kg for women and 282 kg for men[31].

Chauffer's fracture

Radial styloid fractures results from an avulsion force generated through palmar radio carpal ligaments.

Colle's fracture

Fall on outstretched hand; the prominent thenar eminence takes the brunt of the force. The fractures of lower end of the radius occurs while the TFCC is still intact, thus there is a rotatory element with the centre of rotation at the ulnar styloid, the lower end of the radius rotating into supination. If the force continues the ulnar styloid is avulsed. Six deformities occur-

1. Impaction
2. Lateral displacement
3. lateral rotation
4. Dorsal displacement

5. Dorsal rotation
6. Supination

Smith's fracture:

Caused by fall on dorsum of flexed wrist, characterized by fracture of lower end of radius with palmar displacement of distal radial fragment and with a dislocation of distal radio-ulnar joint.

Barton's fracture:

Distal radial fractures that mainly involve the dorsal or volar margin of the articular surface but include an intra-articular component have been referred to as Barton's fracture. Fracture involving the dorsal articular margin of the distal radius and associated with dislocation or subluxation of carpus dorsally have been referred to as dorsal Barton's fracture, whereas fracture of volar articular margin of radius with volar dislocation or subluxation of carpus are referred to as volar Barton's fracture.

Die punch injury: (Lunate load fracture)

Impacted intra-articular fractures have generated interest recently because failure to restore their fractures to within 2 mm of articular congruity particularly in young adults has been shown to lead symptomatic posttraumatic arthritis. Coined “die punch” injuries by Scheck[32], these fractures are generally the result of comprehensive forces delivered through the carpus to the end of the radius[33]. Such fractures are frequently associated with spectrum of injuries including carpal instability, disruption of distal radioulnar joint and local soft tissue injury and have poor outcome[34].

CLASSIFICATION

CLASSIFICATION

Fractures of the distal end of the radius were initially named after the surgeon who reported them. However this presented difficulty in that the eponymous surgeons did not have radiograph available when they originally described these fractures. Newer classification schemes have evolved based on the appearance in the initial radiograph[30].

An ideal classification system must be descriptive, reliable, reproducible, facilitate communication, assist with clinical decision-making & treatment planning and have prognostic value.

These classifications have been based on:

I. Radiographic appearance or fracture displacement direction.
   a. The AO classification
   b. The Lidstorm classification.

II. The mechanism of injury.
   a. The Fernandez classification

III. Articular joint surface involvement.
   a. The Mayo classification
   b. The McMurtry and Jupiter classification
   c. The Melone classification.

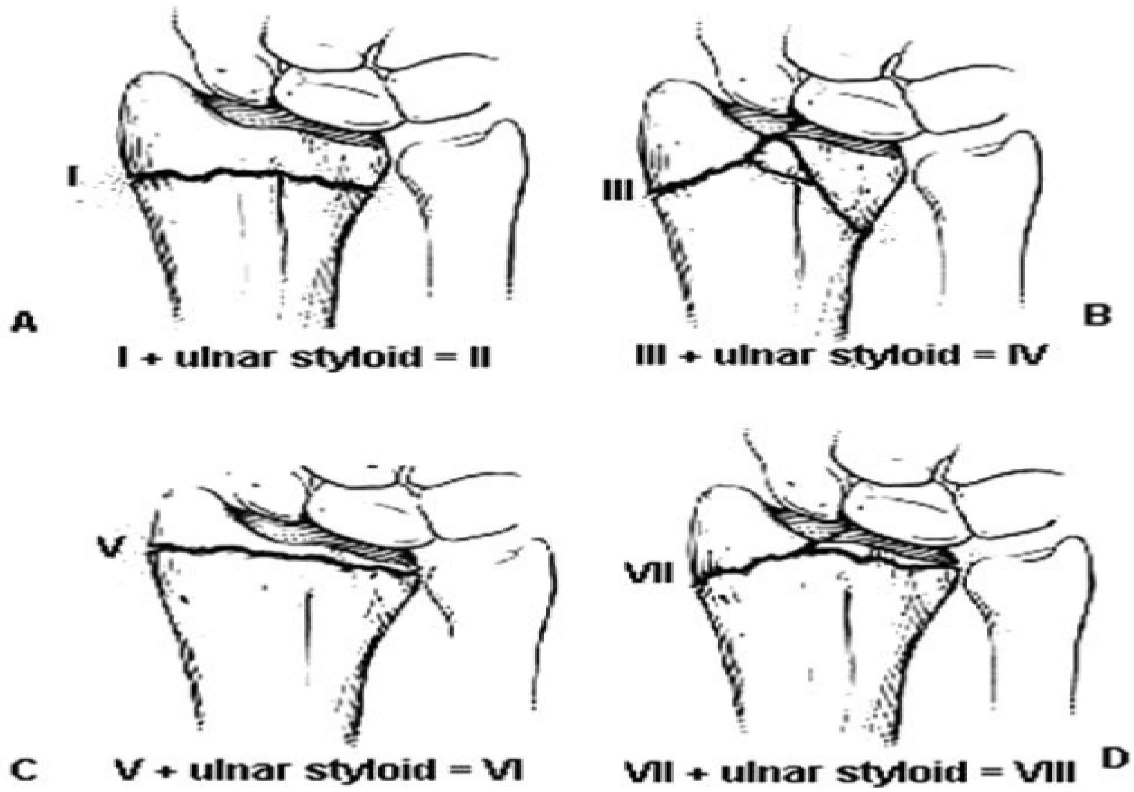
IV. The degree of comminution:
   a. The Gartland and Werley classification.
   b. The Older classification.

Frykman's classification is the most popular, established in 1967. It identified the involvement of radiocarpal and radioulnar joints as well as the presence or absence of a fracture of the ulnar styloid.

FRYKMAN'S CLASSIFICATION OF DISTAL RADIUS FRACTURES[31] (1967):

Fractures	Ulnar styloid Fracture Absent	Ulnar styloid Fracture Present.
Extra-articular	I	II
Intra-articular		
Radiocarpal joint	III	IV
Radioulnar joint	V	VI
Radiocarpal and radioulnar joints	VII	VIII

FRYKMAN'S CLASSIFICATION OF DISTAL RADIUS FRACTURES



GARTLAND AND WERLEY CLASSIFICATION (modified by Sarmiento[35] 1975):

Type IA	: Extra-articular undisplaced
Type IB	: Extra-articular displaced
Type II	: Intra-articular undisplaced
Type III	: Intra-articular displaced

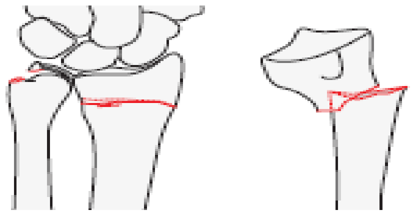
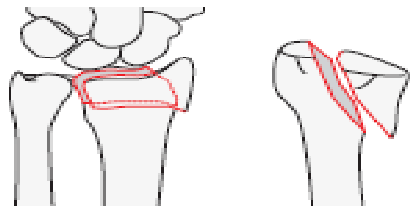
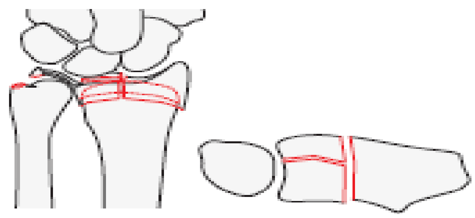
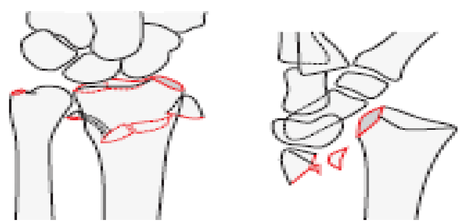
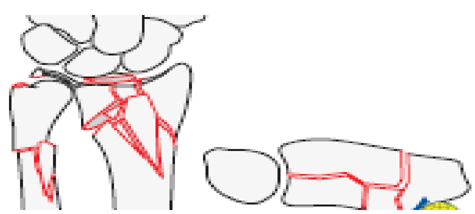
FERNANDEZ CLASSIFICATION[7,36] (1992) :

Fracture type	**Mechanism of injury**
Type I	Bending
Type II	Shear
Type III	Impaction
Type IV	Avulsions with fracture dislocations
Type V	High Velocity External fixation

McMURTRY AND JUPITER CLASSIFICATION[37,38] (1991):

Two parts:	The opposite portion of the radiocarpal joint remains intact. (Dorsal or palmar Barton, Chauffeur and “die punch” fractures).
Three parts:	The lunate and scaphoid facets separate from each other and the proximal portion of radius.
Four parts:	Same as three parts except the lunate facet is further fractured into dorsal and volar fragments.
Five parts:	Including wide variety of comminuted fragments.

FERNANDEZ CLASSIFICATION

Type I Bending fracture of the metaphysis	
Type II Shearing fracture of the joint surface	
Type III Compression fracture of the joint surface	
Type IV Avulsion fractures, radiocarpal fracture, dislocation	
Type V Combined fractures (I, II, III, IV); high-velocity injury	

MELONE'S INTRA-ARTICULAR FRACTURE CLASSIFICATION[39]:

Melone recognized that many intra-articular fractures not only had instability but specific patterns of displacement. He identified that most of the intra-articular fractures have three or four components.

Type I : Intra-articular type, undisplaced with minimal comminution

Type II: Lunate fossa, die-punch fractures with anterior or posterior displacement

Type III: Radial shaft component in addition to above findings.

Type IV: Transverse split fracture with rotation of articular surface.

MAYO CLASSIFICATION OF INTRA-ARTICULAR FRACTURES[2,38,40]:

The goal of both the Melone and Mayo classifications is primarily to call attention to the intra-articular fracture components that require treatment beyond the fracture involving the radial metaphysis and radial shaft.

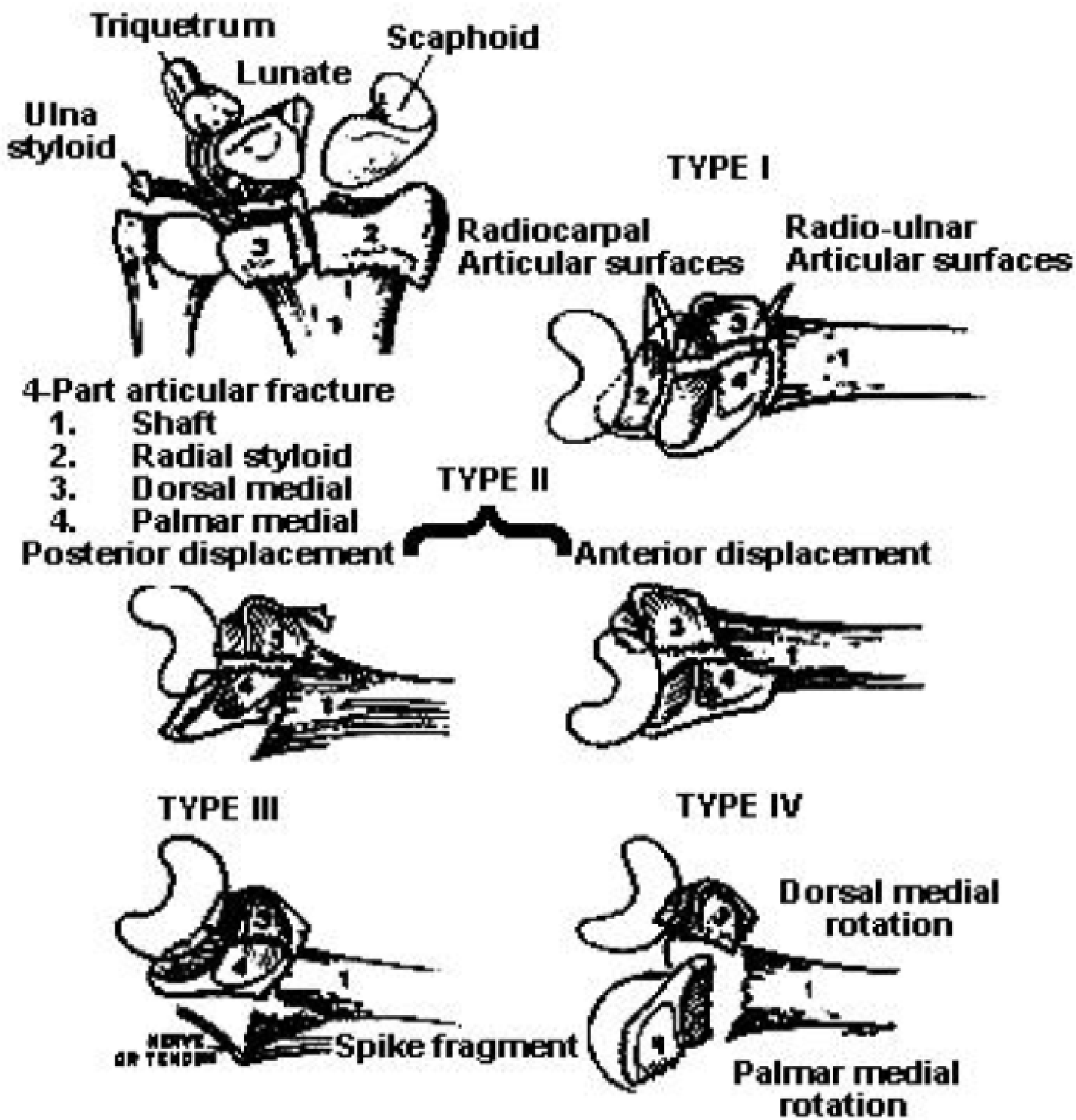
Type-I: Extra-articular radiocarpal, Intra-articular radio ulnar.

Type-II: Intra-articular scaphoid fossa of distal radius.

Type-III: Intra-articular lunate fossa of distal radius + sigmoid fossa.

Type-IV: Intra-articular, scaphoid fossa, lunate fossa and sigmoid fossa of the distal radius.

MELONE'S CLASSIFICATION



LIDSTROM CLASSIFICATION[41,42].

Type-I : Undisplaced.

Type-II:

A. Dorsal angulation, extraarticular.
B. Dorsal angulation, intraarticular but without gross separation of fragments.
C. Dorsal angulation plus dorsal displacement, extraarticular.
D. Dorsal angulation plus dorsal displacement, intraarticular but without gross separation of fragments.
E. Dorsal angulation plus dorsal displacement, intraarticular with separation of fragments.

Older et al classification[41].

Type-1: Non displaced - up to 5° dorsal angulation, radial articular surface at least 2 mm distal ulnar head.

Type-2: Displaced with minimal comminution - dorsal angulation or displacement, radial articular surface no lower than 3 m proximal to the ulnar head, minimal comminution of dorsal radius.

Type-3: Displaced with comminution of dorsal radius - comminution of dorsal radius; radial articular surface proximal to ulnar head; minimal comminution of distal fragment.

Type-4: Displaced with severe comminution of radial head - marked comminution of dorsal and distal radius; radial articular surface 2-8 mm proximal to ulnar head.

UNIVERSAL CLASSIFICATION[2]:

It was proposed in 1990 at symposium conference on fractures of distal radius. This classification system was broadly based on the simple concept and principle of extra-articular versus intra-articular fractures and stable versus unstable fractures.

Type I: Extra articular, undisplaced

Type II: Extra articular, displaced

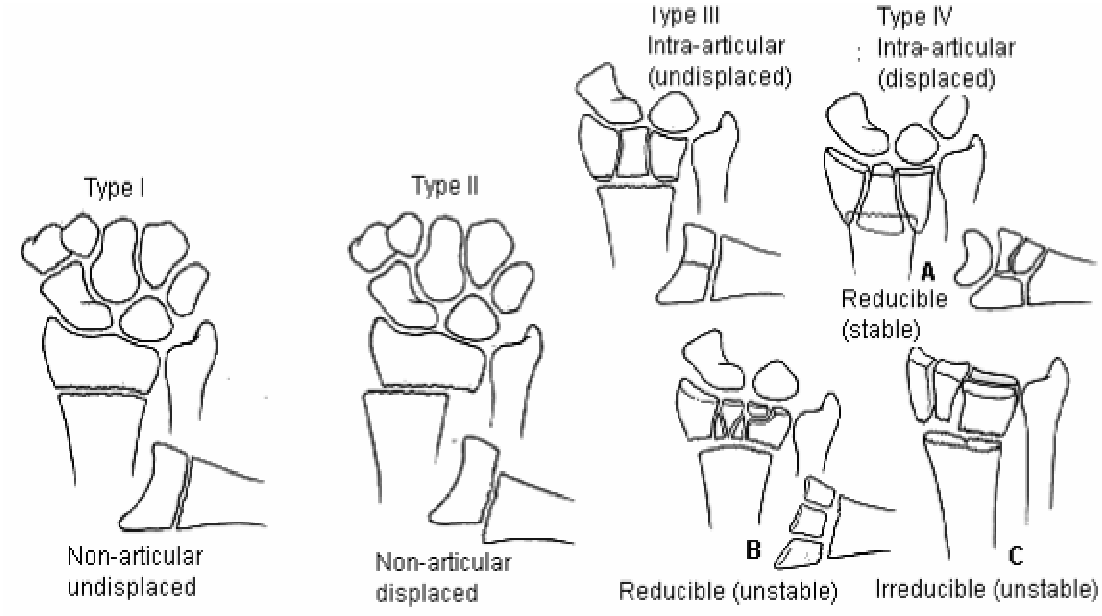
- A. Reducible, stable
- B. Reducible, unstable
- C. Irreducible

Type III: Articular, undisplaced

Type IV: Articular, displaced

- A. Reducible, stable
- B. Reducible, unstable
- C. Irreducible
- D. Complex

UNIVERSAL CLASSIFICATION



AO CLASSIFICATION[38,43,44]:

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

Type A: Extra articular fractures.

A1- Fracture distal to ulna

A2- Fractures distal to radius.

A3- Multi fragmentary fractures distal to radius

Type B: Partial articular fractures.

B1-Chauffer’s fractures

B2- Dorsal Barton’s fracture

B3- Volar Barton’s fracture

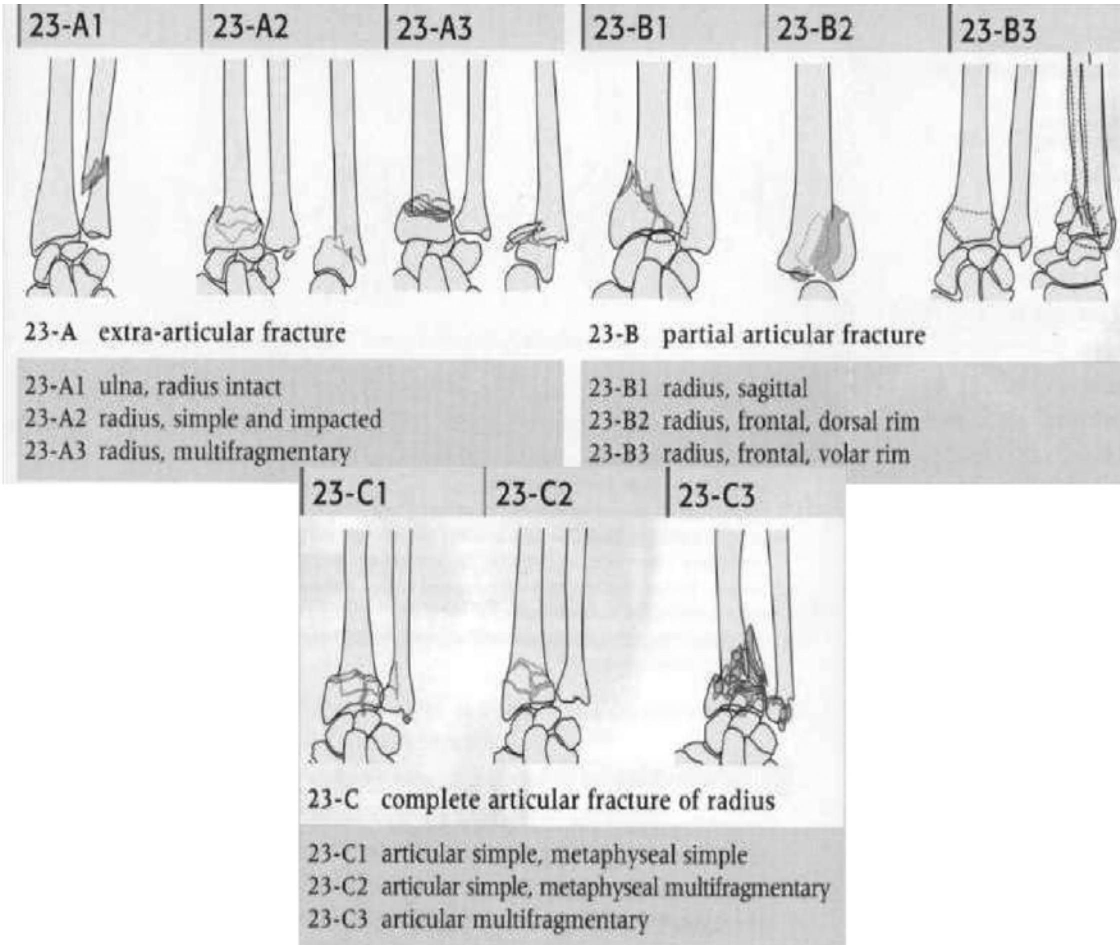
Type C: Articular fractures

C1- Simple articular and metaphyseal fracture

C2-Simple articular and complex metaphyseal.

C3- Complex articular and metaphyseal fractures.

AO CLASSIFICATION



RADIOGRAPHY

RADIOGRAPHIC EXAMINATION

Radiographic measurements have formed the foundation of evaluation of not only the injury but also the outcome of treatment.

Standard x-ray views are anteroposterior, lateral and oblique. Antero-posterior view shows the concave inferior articular surface of lower end of radius extending down to the tip of styloid process.

The parameters assessed:

1. **Radial angulation or inclination –** is the relative angle of the distal radial articular surface to a line perpendicular to the long axis of the radial shaft. This averages 23 degrees (range 13 to 30 degrees).
2. **Radial length –** relates the length of the radius to the ulna by distance between two perpendicular lines to the long axis of the radius, one joining the tip of the radial styloid process and the other, the surface of ulnar head. This averages 11 mm (range 8 to 18 mm).
3. **Ulnar variance –** is the vertical distance between the distal ends of the medial corner of the radius and the ulnar head (range 0 to -2mm).
4. **Radial Shift (Tilt) –** is the displacement of the distal radius in relation to the radial shaft and is measured as the distance between the longitudinal axis through the centre of radius and the most lateral point of the radial styloid. This averages 11 degrees (range 0 to 28 degrees).

Guidelines for acceptable closed reduction as given by Nana AD et al[45] (2005) :

1. Radial inclination: greater than or equal to 15^0 on the postero-anterior view.

2. Radial length: less than or equal to 5 mm shortening on postero-anterior view.

3. Radial Tilt: less than 15^0 dorsal or 20^0 volar tilt on lateral view.

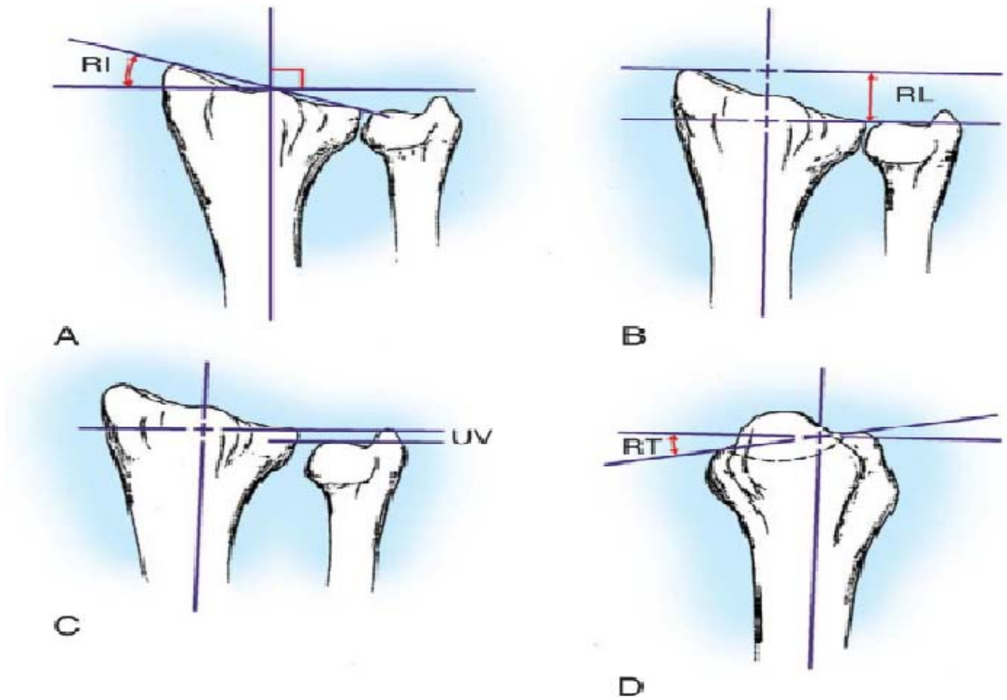
4. Articular incongruity: less than 2 mm of step off.

Radiographic signs that alert the surgeon, that the fracture is probably unstable and closed reduction alone will be insufficient include the following[46]:

1. Dorsal comminution greater than 50% of the width laterally
2. Palmar metaphyseal comminution
3. Initial dorsal tilt greater than 20 degrees
4. Initial displacement (fragment translation) greater than 1 cm
5. Initial radial shortening more than 5 mm
6. Intra-articular disruption
7. Associated ulna fracture
8. Severe osteoporosis

The radiographic parameters assessed:

Radial inclination Radial length



Ulnar variance Radial tilt

VARIOUS MODALITIES OF TREATMENT

VARIOUS MODALITIES OF TREATMENT

The basic principle of treatment is to obtain accurate fracture reduction and to maintain the reduction while protecting the wrist in a functional position so that hand can be rehabilitated. The treatment option advocated ranges from the use of bandage to various forms of operative fixation including the use of bone cement.

The various methods are.

1) Splints
2) Different methods of cast application
3) Percutaneous pinning.
4) Pins and plaster.
5) External skeletal fixation.
6) Open reduction and internal fixation.

Splints:

William cassebaum[47] (1950) has treated 361 cases of colle's fractures with dorsal and volar splints following closed manipulation. The functional end results were good in 94% of cases in that series. According to him, this method cannot prevent shifting and shortening of oblique or comminuted fractures. This method fails to prevent some anatomic deformity from occurring in many cases and resulted in painful disabled hand as the most common complication.

Small (1965) reported good subjective results with cast immobilization. In these series no distinction has been made between intra and extra articular fractures, fracture severity and hence cannot be applied to intra articular fractures.

Different methods of cast application:

A myriad of opinions exist about the correct mode of cast immobilization after manipulation. Varying flexion with ulnar deviation at wrist and forearm in full prone postion of the hand in the plaster are three factors which vary in the literature.

In a prospective comparative study Pool (1973) used several methods of treatment and found results with below elbow cast better than high plaster cast and concluded that short arm cast was enough to prevent rotation of fragments. According to Bohler (1953) the forearm should be fixed somewhat midway between pronation and supination.

Sarmiento[48] (1965, 1975) recommended immobilization of the forearm in supination. He stated that the brachioradialis muscle is the muscle which causes typical re-dislocation in distal fractures of radius and is the chief deforming forces which gets augmented in full prone position of the forearm. He has shown with the aid of EMS studies, that the brachioradialis muscle functions when forearm is in pronation and in supination, its activity is reduced. He consequently recommended this position as being the best for avoiding redisplacement of fracture.

Accounting to Wahlstrom's (1982) study, three different position of POP cast application were undertaken. The wrist and forearm were immobilized in a plaster cast in pronation, in mid-position and in supination. According to him the role of pronator quadratus is given equal importance as that given to the brachioradialis. The pronator quadratus muscle contracts mainly when the forearm is in supination. This position makes an unsuitable one for immobilization in supination. He concluded that at this juncture, our knowledge of how dislocation occurs in colle's fracture is not sufficient to decide on a theoretical basis which position of immobilization is the best.

Percutaneous pinning

Extra-articular fractures with extensive comminution that have no more than two articular fragments, in which anatomical reduction is obtainable, are amendable to percutaneous pinning of the fracture fragments. This technique was advocated in 1952 by De palma[49], where a threaded K-wire was obliquely introduced through ulna into reduced distal fragment of radius. He reported 18% unsatisfactory results. Dowing and Sawyer (1961) showed 84% good to excellent results with same method. Recently Clancy reported on 30 consecutive patients who had displaced unstable fracture and were treated by closed reduction and percutaneous pinning. Anatomical reduction was maintained in 28 patients, with few complications in the series.

Intrafocal pinning of distal radius fractures was described by Kapandji in 1976, for unstable extra articular fractures of distal radius in young adults. Epinette et al (1982) reported 84% good and excellent results with this technique for intra articular fractures without displacement. Nonnenmacher and Neumeier reported 92% good and excellent results with this technique where 60% patient had intra articular involvement.

Pins and plaster:

In 1929 Bohler[21] published his original technique of transfixation with skeletal pins in metacarpals and bones of forearm and incorporation in plaster to maintain reduction of fractures; the so called “pins and plaster method” and showed significantly better results than the old methods. But it reached the widespread popularity after the report by Green[50] in 1975 who documented good or excellent results in 86% of patients. However Green noted a high incidence of both minor and major complications, with 13% of patients having problems related to the pins. Recent studies have corroborated the findings of a substantial incidence of complications with this technique.

Chapman[51] et al also noted that 1/3rd of complications were related to the pins and that 16% of the patients needed re operation for complications. In a series of fractures caused by high energy trauma, Webes and Szabo[52] reported complications in more than 30% of their patients.

Although pins and plaster offers a method of maintaining reduction of many unstable fractures at limited expenses, the complication of incorporating into circumferential plaster have led to a re-evaluation of this technique.

External fixation:

In 1944 Roger Anderson described the prototype of today’s external fixator for treatment of distal end of radius. He was one of the earliest to analyze the cause of poor results as shortened radius, malunited irregular joint surface and emphasized that shortening was not only due to impaction and overriding but also due to actual crushing of the juxta articular cancellous bone and hence devised a fixator that maintained sustained traction to maintain reduction. He reported good results particularly in elderly osteoporotic bones. Since then, external skeletal fixation has become increasingly popular in the management of complex fractures of the distal end of radius. A number of series have reported favorable results with external fixation but incidence of complications like pin tract infection, stiffness etc were high, ranging from 20 to 60%.

In a land mark study in 1979, conducted by Cooney et al[5] reported 90% excellent and 8% fair results in comminuted intra articular fractures of distal radius. Some authors have also recommended decreasing the amount of traction that is applied by external fixation frame across the radiocarpal ligaments after 3 weeks there by limiting treatment duration and by supplementing it with percutaneous pins or autogenous bone grafting.

OPEN REDUCTION AND INTERNAL FIXATION

OPEN REDUCTION AND INTERNAL FIXATION

Complex intra-articular fractures of the distal radius continue to pose a therapeutic challenge. Because of the importance of the radiocarpal and distal radiocarpal articulations to forearm and hand, significant disability results from malunions of the wirst consequent to fractures. Although the wrist does not bear weight, its function is considerably compromised by malunion.

In an attempt to restore normal anatomy after distal radius fractures, measures of articular orientation have included radial tilt in the sagital plane (normal 11^0 volar) and radial length as measured by ulnar variance. If fracture heals with 20° dorsal tilt, grip strength and endurance decreases.

If radial inclination decreases to 10^0 or less, it has been shown with pressure sensitive films that abnormal load bearing patterns on the articular surface of the distal radius will occur which will have deleterious mechanical effects.

Restoration of bony anatomy is only one component for treatment of these fractures. Soft tissue injuries are often extensive. It often influences or even compromises treatment of the overall injury and certainly may be a source of complications to the injury. Although stable fractures can usually be reduced and held in casts, unstable fractures are often doomed to failure with such treatment.

No hard and fast rules exist for assessing stability, but certain guidelines can be given.

a. Significant comminution usually indicates instability.
b. Osteoporotic bones are frequently comminuted in an extra-articular metaphyseal location, either dorsal or volar. Dorsal comminutions occuring through an area of 50% or more than the metaphyseal diameter of the bone often causes collapse and increased dorsal tilt of the articular surface.
c. Articular comminution with displacement or articular step-off of more than 2mm or angulations of major fracture fragments more than 10^0 may indicate instability.

Therefore, with recognition of gross instability one should choose a method of fracture treatment that imparts stability. If initial attempts at closed reduction fail, careful attention should be given to increasing the stability of the fracture by surgical means because it is clearly established that re-reduction and continued closed treatment will often fail. Collert and Isacson found that 87% of fractures displaced a second time if re-reduction was performed within 1 to 6 days after initial reduction and that 50% displaced again if manipulated within 7 to 15 days after initial reduction.

Basic principles of surgical fracture treatment of the distal radius are:

1. Anatomic articular reconstruction is of paramount importance as articular incongruity leads to arthritis.
2. Failure to restore the normal three-dimensional orientation of all joint surfaces leads to increased stress across the joint and contact forces that eventually lead to joint pain and degenerative arthritis.
3. Fixation devices must gain adequate purchase in bone.

4. Comminution reduces stability and requires fixation devices of increased stability e.g., Kirschner wires.
5. Buttressing devices often have no fixation directly into articular fragment(s), but by virtue of their placement they prevent displacement.
6. When possible fixation devices such as Kirschner wires and screws should be inserted perpendicular to the fracture site. In such a position maximum resistance to shear stress is obtained.
7. Bone graft serves two distinct purposes: Structural support when comminution or bone loss has weakened the construct and osteo induction to hasten healing.
8. Always check the patient for neurovascular compromise. With increasing awareness, diagnosis of median or ulnar nerve dysfunction is being made more frequently with distal radius fractures.

Thus keeping the above principles in consideration and recognizing the instability criteria, following indications can be evolved for fractures of distal end of radius, to be treated with open reduction and internal fixation:-

1. Extra-articular fractures which are open combined with extensive soft tissue or tendinous involvement, non reducible secondary to soft tissue interposition or combined with metaphyseal or diaphyseal comminution requiring bone graft.
2. Dorsal Barton's fracture with large fragment.
3. Volar Barton's fracture (displaced).
4. Displaced intra-articular fracture without metaphyseal comminution..

i) with organized haematoma.

ii) with soft tissue interposition at fracture site.

iii) which prevents closed reduction.

5. Simple articular component with dorsal metaphyseal comminution and volar cortical comminution

6. Decreased radial height of greater than 3-4mm.

7. When closed reduction fails to restore normal anatomical palmar tilt.

8. Distal radial fracture in the presence of dysfunctional contralateral limb

9. Bilateral injuries.

Ellis[15] (1965) was one of the earliest to recommend open reduction and internal fixation for volarly displaced fractures of the Smith's or Barton's type. He devised a T-shaped plate which acted as an excellent volar buttress preventing the deformity.

Lee BP and Tan CT (1992) conducted a study, in a series of 15 patients with comminuted intra-articular fractures of distal radius treated with T-plate. They had 46% completely pain free results and remaining 54% had mild pain associated with forceful activities involving the wrist, with all patients having a functional range of motion. They recommended open reduction and internal fixation to achieve articular congruency in comminuted distal radius fractures[53].

MATERIALS AND METHODS

MATERIALS AND METHODS

SOURCE OF DATA:

Our study was conducted between the period of October 2010 to April 2012 in B.L.D.E University, Shri. B. M. Patil Medical College and Research Centre, Bijapur. 32 patients with displaced, comminuted, intra-articular fractures of distal end of radius were treated by open reduction and internal fixation with buttress plates.

METHODS OF COLLECTION OF DATA

Patient selection:

Varying pattern of intra-articular fractures of the distal end of radius is common in adults. These injuries are commonly referred as Colle's, Barton's or Smith's fractures, depending on the involvement of the distal radio-ulnar and radio-carpal joint surfaces and the displacement of the fracture fragments. Some of these fractures however are caused by severe trauma, and resulting comminution may defy inclusion in a single eponymous group.

In our series cases were selected from patient with fracture distal end of radius classifiable on the Frykman classification system. Radiographic assessment of wrist:- antero-posterior and lateral view were taken, analysis of the articular involvement and extension of fragments in to diaphysis was done.

All the patients selected for the study were admitted, examined according to the protocol, associated injuries if any were noted and clinical and laboratory investigations were done in order to get fitness for surgery. Open reduction and internal fixation by buttress plate and screws was done in all patients within 5-7 days of initial trauma. Follow up and assessment at 6 weeks, 3 months, 6 months, final evaluation was performed at 6 months using demerit-point system of Gartland and Werley[9].

SAMPLE SIZE:

With the proportion rate of fracture of the distal end of radius in all forearm fractures is 75%[54], 95% confidence limit and 20% clinically expected variation the calculated sample size was 32, using the statistical formula

$$n = \frac{(1.96)^2 P (100-P)}{L^2}$$

P=incidence rate=75% L=expected variation

INCLUSION CRITERIA :

a. Patients who had been diagnosed of fracture distal end of radius.

b. Age group of above 18 years.

c. Patients who were fit for surgery.

EXCLUSION CRITERIA:

a. Age group of less than 18 years.

b. Patients not fit for surgery.

c. Open fractures.

d. Associated other bony injuries to ipsilateral limb.

SURGICAL APPROACHES AND TECHNIQUE :

In our series all patients underwent open reduction and internal fixation by buttress plate and screws. The aim was to restore the radio-carpal, radio-ulnar joint congruity and to regain radial length. The fractures were approached according to the direction of the displaced fragment.

The surgery was carried out under general anesthesia or brachial block after thorough preparation of the parts.

Surgical exposure:

Volar approach:

In planning the surgical approach, it is important to consider the anatomy of the fracture surface. A longitudinal incision about 7.5 cm long taken on the radiovolar aspect. The plane between the Flexor carpi radialis and the Palmaris longus was developed. The Flexor pollicis longus tendon was retracted radially and the median nerve and the other tendons were retracted towards ulna. The fibers of the pronator quadratus were severed from their origin on the radius and the fracture was exposed. Fracture was reduced and a buttress plate was contoured so that when it is applied and fixed to the proximal fragment, the distal transverse part will act as a buttress and hold the fracture reduced. A minimum of two screws were inserted in the proximal fragment. Whenever possible, screws were inserted through the distal part of the plate into the fracture fragments. The reduction of the fracture and restoration of the articular surface was confirmed by direct observation and by antero-posterior and lateral views in C arm. Pronator quadratus was placed over the plate to its origin on the radius and wound was closed.

Dorsal approach:

The dorsal surgical approach is more straightforward, because fewer soft tissue structures need exposure. A longitudinal, midline skin incision provides excellent exposure. The plane of dissection is between the second and third compartment. In a similar manner, the articular fragments can be seen by extension of the approach through the dorsal capsule and fracture exposure is accomplished. Dorsal buttress plate contoured over the distal radius. Reduction checked under image intensifier. A minimum of two screws inserted in the proximal fragment. Whenever possible, screws were inserted through the distal part of the plate into the fracture fragments and wound closed in layers.

POST OPERATIVE PROTOCOL

After the surgery, the operated limb was supported with an anterior or posterior splint and was kept elevated for 3 days till the edema subsided. All the patients received antibiotics, analgesics and anti-inflammatory drugs to prevent infection and to relieve pain and swelling. Active movements of the fingers, elbow and shoulder were started on the first post operative day. On the 3rd postoperative day, the operated wound was inspected and active movements of fingers and wrist were encouraged and the range of movements depending upon the tolerance of pain by the patients. As the patient's tolerance to pain increased they were motivated for more vigorous physiotherapy regime.

Sutures were removed on 10-12th post operative day. The splints were discarded and were replaced by a crepe bandage and patients were advised to carryout normal activity within the crepe bandage and resistant major activities. Non compliant patients were advised to wear the splints till the first follow-up.

All the patients were reviewed at the 6th week, 3rd month and 6th month postoperatively and were evaluated clinically and radiologically.

Patients were enquired regarding pain, restriction of motion, disability and grip strength. Clinical examination regarding the movements at the wrist and fingers were done. Careful examination was done to rule out any infection.

Radiological examination consisted of assessing the consolidation of the fracture site, collapse at the fracture site and any displacement of the implant.

The final evaluation was done on the 6th month. The patients were evaluated according to standard objective and subjective criteria using demerit-point system of Gartland and Werley[9].

The longest follow-up in this series was 10 months.

DEMERIT POINT SYSTEM OF GARTLAND AND WERLEY[9]

RESIDUAL DEFORMITY (point range 0-3)	Points
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	2-3
SUBJECTIVE EVALUATION(point range 0-6)	
Excellent : no pain,disability,or limitation of motion	0
Good : occasional pain,slight limitation of motion,no disability	2
Fair : occasional pain, limitation of motion,feeling of weekness Activities slightly restricted	4
Poor : pain, limitation of motion,disability, activities more or Less restricted	6
OBJECTIVE EVALUATION (point range 0-5)	Points
Loss of dorsiflexion	5
Loss of ulnar deviation	3
Loss of supination	2
Loss of palmar flexion	1
Loss of radial deviation	1
Loss of circumduction	1
Pain in distal radio ulnar joint	1
Grip strength-60% or less of the opposite side	1

COMPLICATIONS (point range 0-5)

Arthritic changes	Points
Minimum	1
Minimum with pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complications (median)	1-3
Poor finger functions	1-2

The objective evaluation is based upon the following range of motion as being the minimum for normal function; dorsiflexion, 45 degrees; palmar flexion, 30 degrees; radial deviation, 15 degrees; ulnar deviation, 15 degrees; pronation, 50 degrees; and supination, 50 degrees.

END RESULT POINT RANGE :

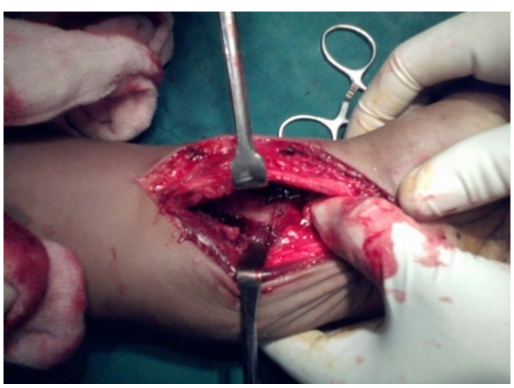
Excellent	:	0-2
Good	:	3-8
Fair	:	9-20
Poor	:	21 and above

OPERATIVE PHOTOGRAPHS

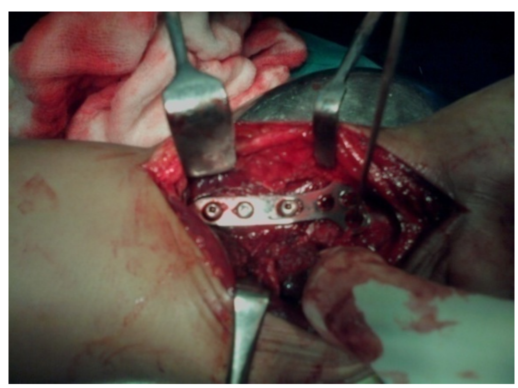
Instruments for Buttress plating

Buttress plates

Incision over the volar aspect



Fracture site exposed

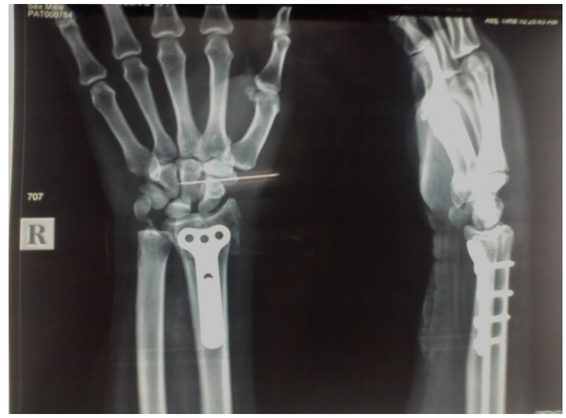


Fracture reduced and buttress plate applied

RADIOGRAPHS

RT DISTAL RADIUS FRACTURE

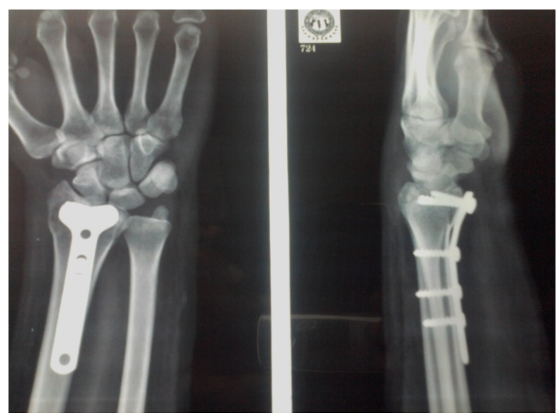
PREOPERATIVE



POSTOPERATIVE

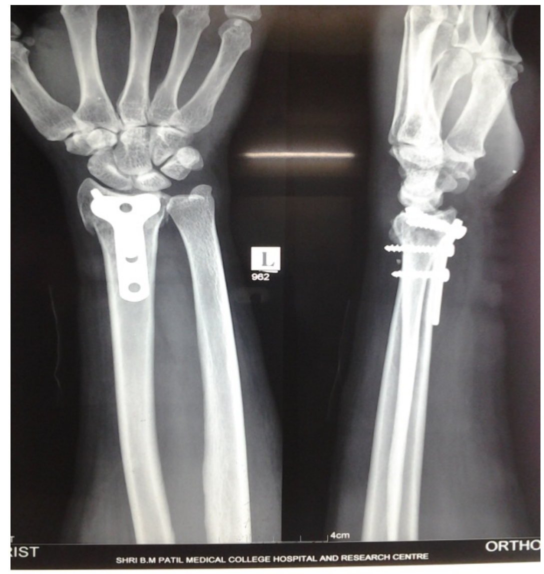
LT DISTAL RADIUS FRACTURE

PRE OPERATIVE



POST OPERATIVE

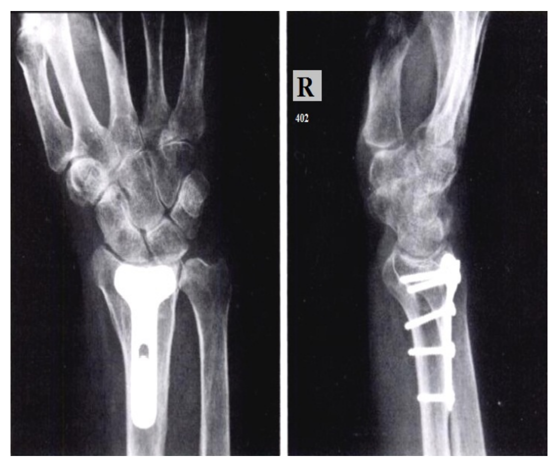
RADIOGRAPHS



LT DISTAL RADIUS FRACTURE

PRE OPERATIVE

POST OPERATIVE



RT DISTAL RADIUS FRACTURE

PRE OPERATIVE

POST OPERATIVE

PHOTOGRAPHS SHOWING EXCELLENT RESULTS

FLEXION

EXTENSION

SUPINATION

PRONATION

PHOTOGRAPHS SHOWING GOOD RESULTS

FLEXION

EXTENSION

SUPINATION

PRONATION

PHOTOGRAPHS SHOWING GOOD RESULTS

FLEXION

EXTENSION

SUPINATION

PRONATION

OBSERVATION AND RESULTS

OBSERVATION

AGE INCIDENCE:

Age in year	No. of patients	Percentage. %
20-29	11	34.3
30-39	7	21.8
40-49	5	15.6
50-59	3	9.3
60-69	6	18.7

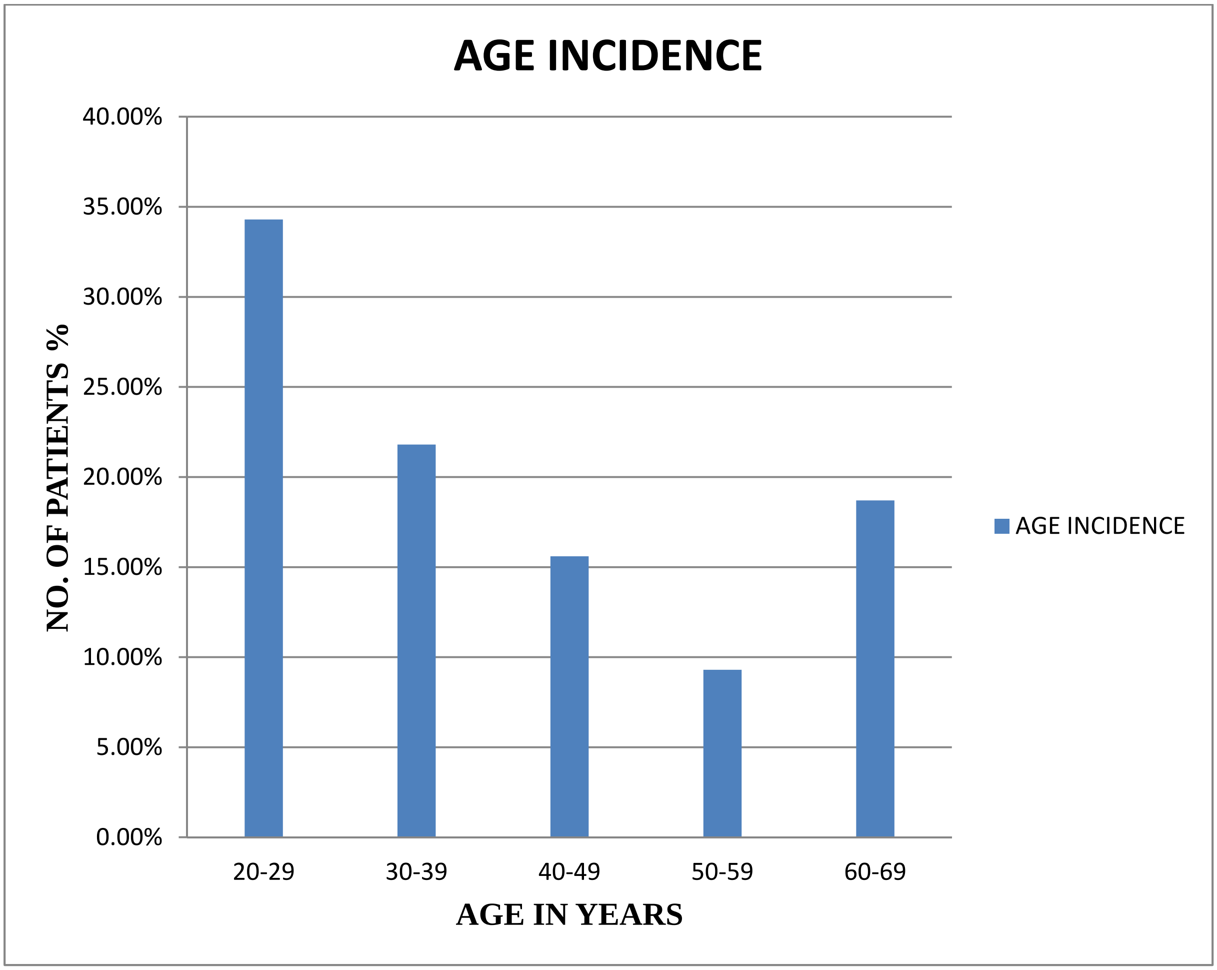
Youngest patients in this series was 21 years and eldest was 69 years old.

SEX INCIDENCE:

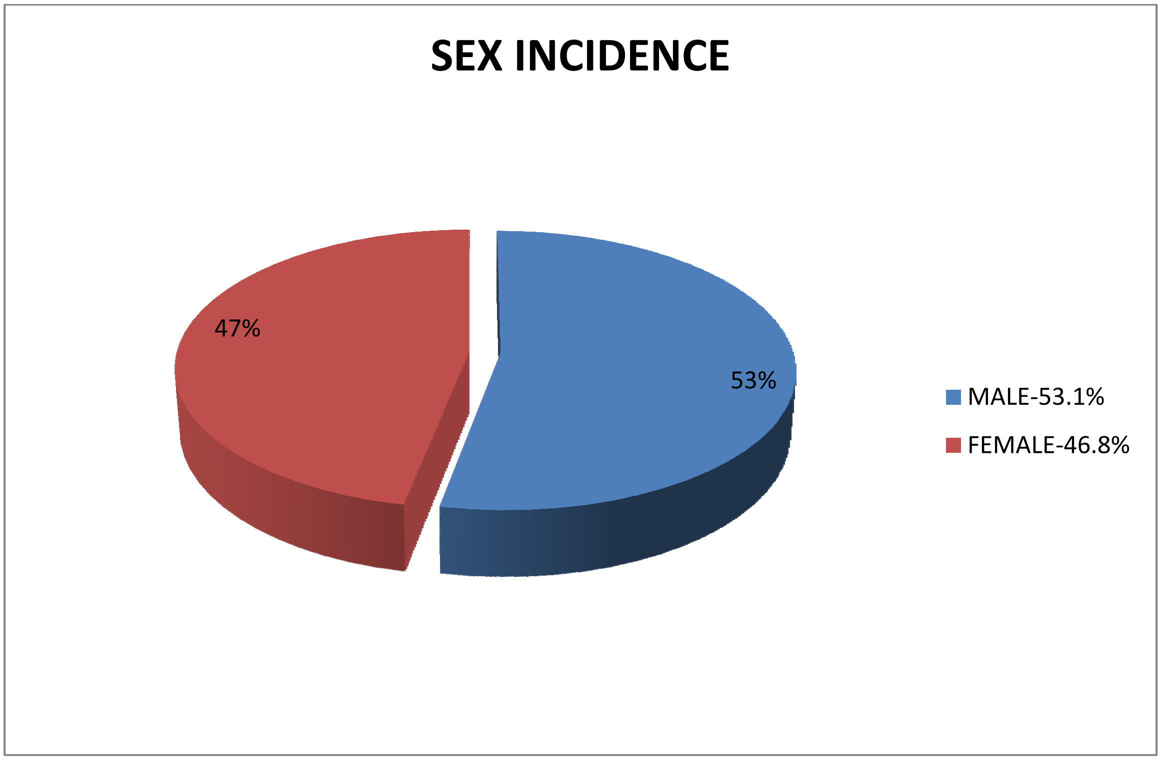
Sex	No. of patients	Percentage. %
Male	17	53.1
Female	15	46.8

Male patients > female patients

GRAPH SHOWING AGE INCIDENCE



PIE CHART SHOWING SEX INCIDENCE



SIDE OF INVOLVEMENT:

Side involved	No of patients	Percentage. %
Right	23	71.8
Left	9	28.1

Distal end radius fractures were seen more commonly on right side.

MODE OF INJURY

Mechanism	No of patients	Percentage. %
R T A	13	40.6
Fall on outstretched hand	8	25
Fall from height	7	21.8
Direct injury	4	12.5

In our study the most common mode of injury causing distal end radius fractures was Road traffic accident (RTA) 40.6%, followed by fall on outstretched hand with incidence of 25%.

FRYKMAN TYPE AND MODE OF INJURY:

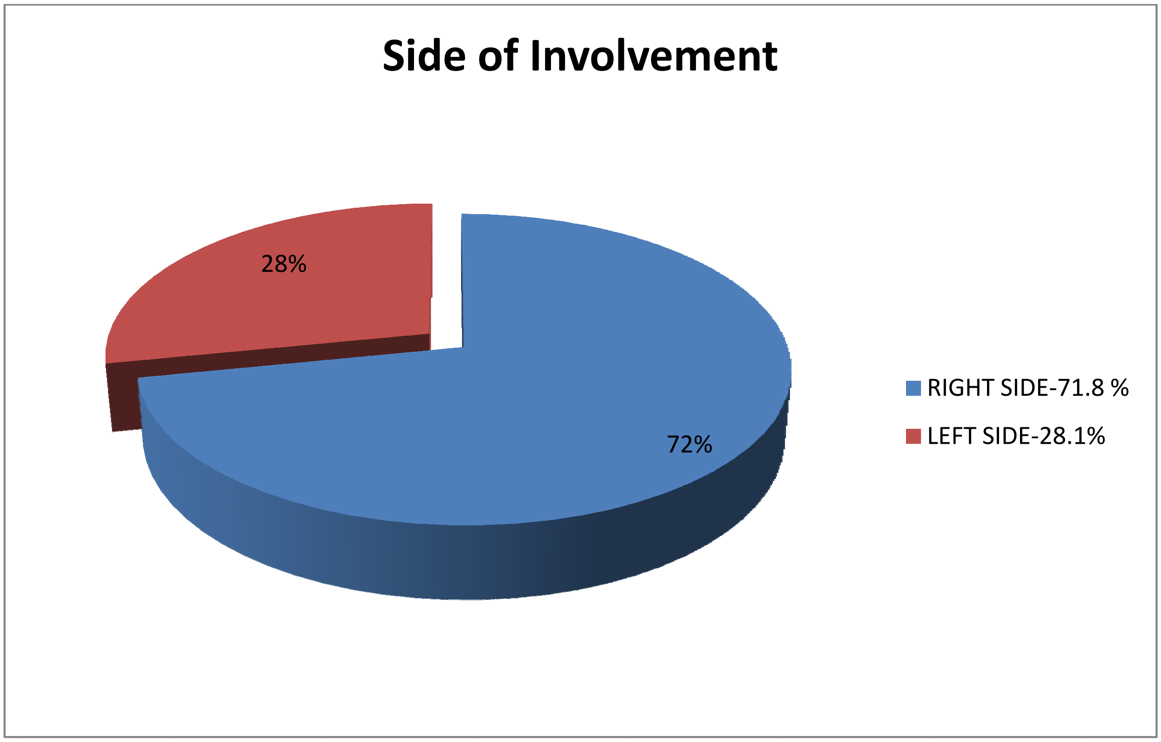
Mode of injury	FRYKMAN TYPE								Total	%
	I	II	III	IV	V	VI	VII	VIII		
RTA	-	-	2	-	2	1	7	1	13	40.6
Fall On Outstretched Hand	-	-	5	-	1	-	2	-	8	25
Fall From Height	1	-	3	-	2	1	-	-	7	21.8
Direct injury	1	-	2	-	1	-	-	-	4	12.5
Total	2		12		6	2	9	1	32	

Frykman type VII fractures of distal end radius was observed more commonly due to RTA mode of injury and Frykman type III fracture of distal end radius was more seen in the fall on outstretched hand. In our study maximum number of cases was of Frykman type III fractures, 12 cases followed by Frykman type VII fractures, 9 cases.

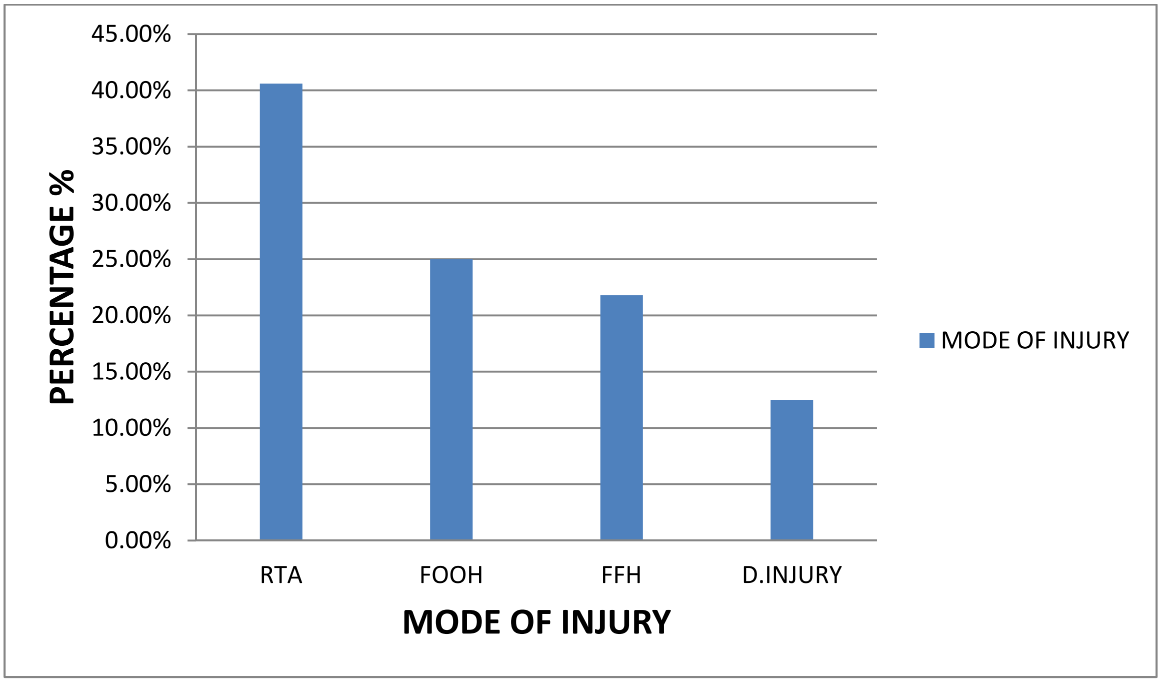
BONE GRAFTING:

Bone grafting was done in 6 patients. All the patients were above 40 years of age. Bone grafting was done for severe comminuted and age related osteoporosis.

PIE CHART SHOWING SIDE OF INVOLVEMENT



GRAPH SHOWING MODE OF INJURY



RTA- Road traffic accident

FOOH- Fall on outstretched hand

FFH- Fall from height

D.injury- Direct injury

RESULTS

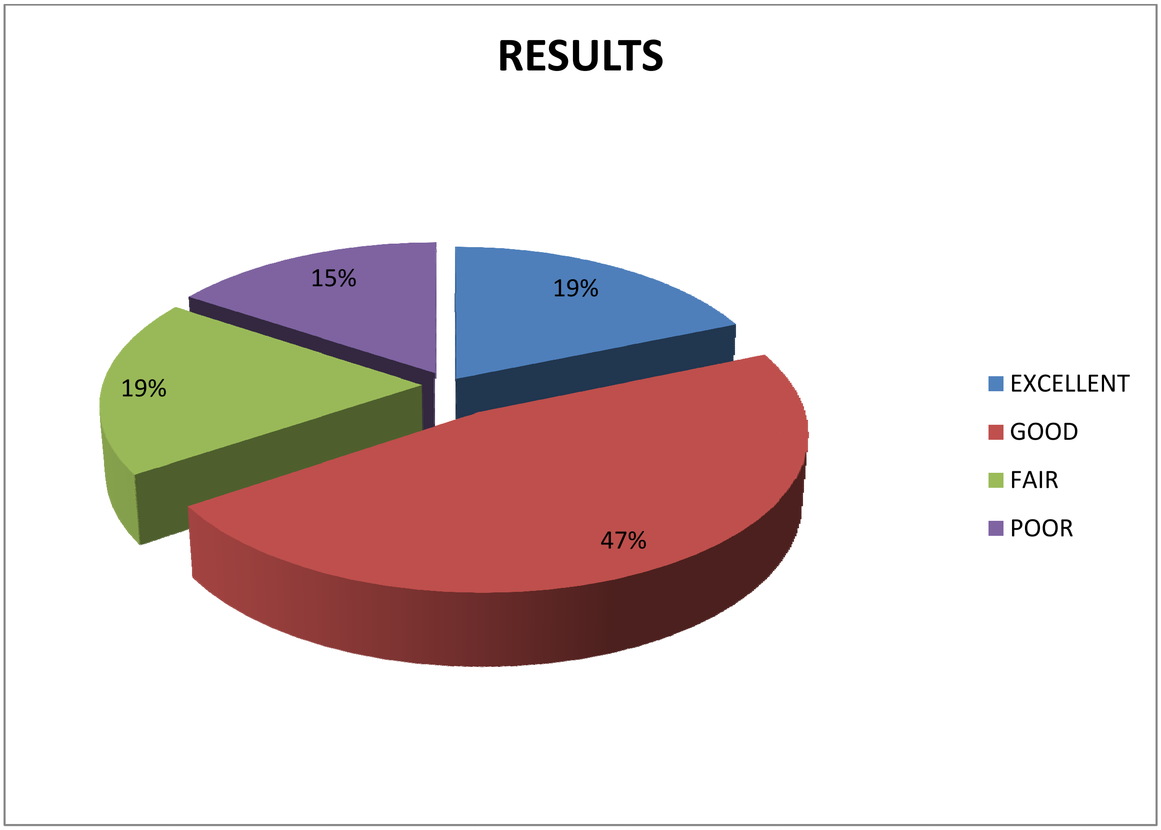
Final evaluation in our series was done at 6 months follow up on the basis of demerit point system of Gartland and Werley[9].

The minimum duration of follow-up for final evaluation in our series was 6 months. The maximum duration was up to 10 months.

In our series 6 patients had excellent results accounting for 18.7%, 15 patients had good results accounting for 46.8%, 6 patients has fair results accounting for 18.7% and 5 patients had poor results accounting for 15.6%.

Results	**No. of patients**	**Percentage. %**
Excellent	6	18.7
Good	15	46.8
Fair	6	18.7
Poor	5	15.6

PIE CHART SHOWING PERCENTAGE OF RESULTS



EVALUATION OF RESULTS IN FRYKMAN TYPES :

RESULTS	FRYKMAN TYPE								TOTAL
	I	II	III	IV	V	VI	VII	VIII	
Excellent	-	-	4	-	-	-	2	-	6
Good	2	-	6	-	4	2	1	-	15
Fair	-	-	2	-	1	-	2	1	6
Poor	-	-	-	-	1	-	4	-	5

Poor results were seen more in Frykman type VII injuries.

MODE OF INJURY:

MODE OF INJURY	RESULTS				Total
	E	G	F	P	
R T A	3	5	2	3	13
Fall on outstretched hand	2	2	3	1	8
Fall from height	1	4	1	1	7
Direct injury	-	4	-	-	4

SEX:

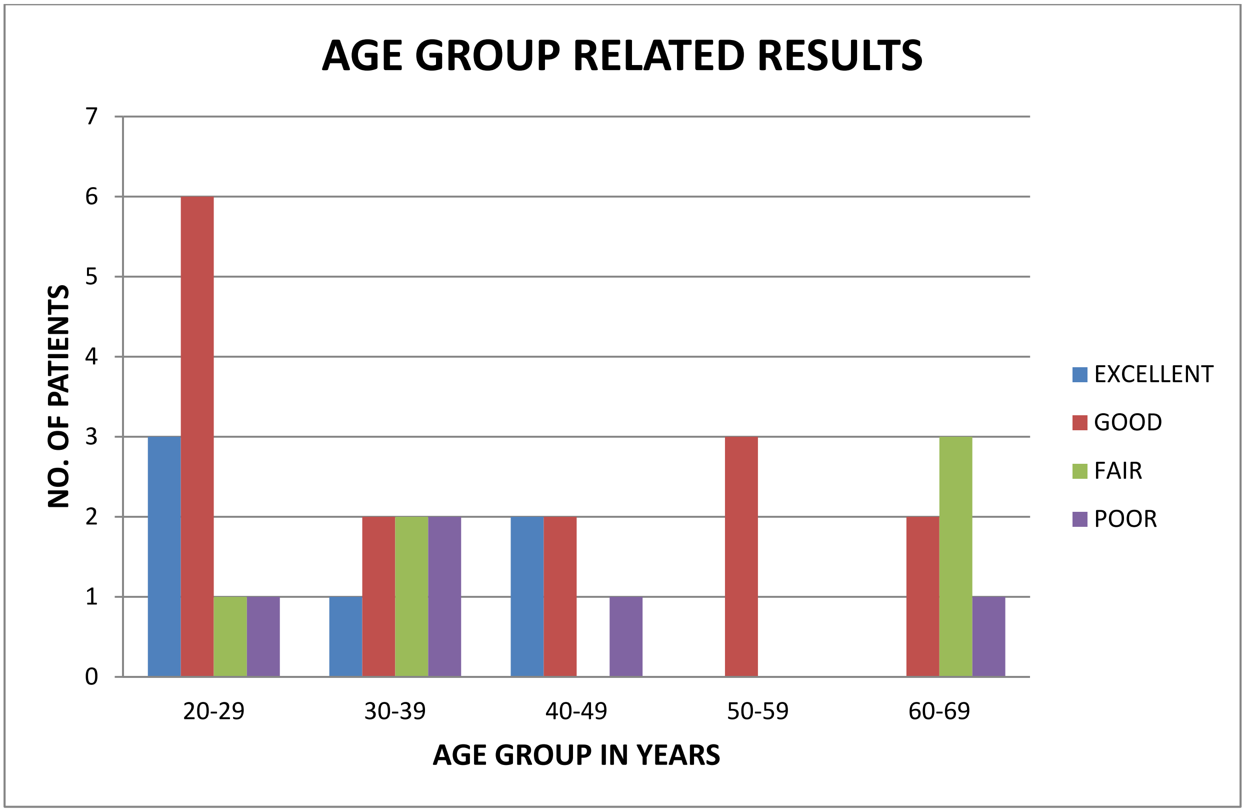
SEX	RESULTS				TOTAL
	E	G	F	P	
MALE	4	6	3	4	17
FEMALE	2	9	3	1	15

AGE:

AGE GROUP	RESULTS				TOTAL
	E	G	F	P	
20-29	3	6	1	1	11
30-39	1	2	2	2	7
40-49	2	2	-	1	5
50-59	-	3	-	-	3
60-69	-	2	3	1	6

These results show that Excellent and Good results were more commonly seen in patients of age group 20 to 40 years.

GRAPH SHOWING AGE GROUP RELATED RESULTS



DISCUSSION

DISCUSSION

This study was undertaken to assess the functional outcome of operative management of distal radial fractures in adults by open reduction and internal fixation by buttress plates and screws.

Increased awareness of the complexity of Colle's fracture has stimulated a growing interest and prompted new ideas regarding their optimal management. Although closed reduction with cast immobilization remains a reliable standard method of treatment for stable extra articular fractures and minimally displaced articular injuries, similar management for unstable articular disruption is prone to failure. The best method of obtaining and maintaining an accurate anatomy remains a topic of considerable controversy. However recent critical evaluation of fracture pattern and results of treatment have demonstrated the need for surgical intervention.

In our study, Frykman's classification was used for classification of the fracture type. In this study we have used buttress plates for distal end radius fractures. In our study the number of male patients were more than female patients.

They were best handled by open reduction and internal fixation by buttress plates. It should be emphasized that these fractures not only have gross displacement of fragments but also have compressed and crushed juxta-articular fragments which is of no supportive value. A buttress purchasing instrument provides a good hold on proximal fragments and lays a very important role by contributing to the stability.

In our study 32 patients were treated with buttress plates for comminuted intra-articular, unstable extra-articular fractures of distal end of radius, followed up for a minimum of 6 months, were analyzed according to the criteria of demerit point system of Gartland and Werley[9]. 6 patients had excellent results (18.7%), 15 patients had good results (46.8%), 6 patients had fair results (18.7%) and 5 patients had poor results (15.6%).

A study was conducted by John K. Bradway and William P Cooney on 16 patients with comminuted intraarticular fractures of distal radius, with a mean follow up of 5.7 years. The evaluation was based on the criteria of Garland and Werley and also by Green and O'Brien scoring system. They had 56% of their patients rated excellent, 25% good and 19% fair[16]. They had no poor results. This high percentage of excellent and good results compared to our study may be due to fact that the follow up was of longer duration and they had better patient's compliance. Bone grafting was done in more number of patients.

In our series 18 patients were below the age of 40 years. 6 patients were between 40-50 years and 4 patients were between 50-60 years and 4 patients were above 60 years. The average age of 32 patients was 39.37 years.

In the series of Bradway and Cooney[16], the average age of the 16 patients were 40 years. The youngest being 18 years and oldest being 75 years. Thus compared to this series the average age of the patients in our study was almost similar and there were high incidence of male patients in our series.

In our study involvement of right side (71.8%) was more than the left (28.1%). The right side was dominant for all the patients with right side involvement. This may be due to fact that dominant extremity reaches out first to have first impact of trauma. In our series the mode of injury in 13 patients were due to RTA (40.6%), 8 patients sustained injury due to fall on outstretched hand (25%), 7 due to fall from height (21.8%) and 4 patients (12.5%) sustained a direct blow.

In the series of Bradway and Cooney[16], the commonest mechanism was fall on outstretched hand, seen in 11 patients (69%) and RTA in 4 patients (31%).

The final result in our series after an average follow up of 7 months (6-10 months) showed that 6 patients (18.7%) had excellent result. Of these 2 patients were above 40 years and 4 were below 40 years. 4 patients had Frykman type III and 2 patients had type VII fractures. 3 patients had their trauma due to RTA, 2 patients had sustained injury due to fall on outstretched hand and one patient due to fall from height.

15 patients (46.8%) in our series had good result. 10 patients were below 50 years of age and 5 patients were above 50 years. Of this 6 patients had Frykman type III injury, 4 had type V, 2 had type VI, 2 had type I and 1 had type VII injury. The mode of injury in 5 patients were due to RTA, 2 patients had fall on outstretched hand, 4 had injury due to fall from height, and 4 due to direct injury.

6 patients (18.7%) in our series had fair results. 3 patients were over 60 years of age. 3 patient sustained injury due to fall on the outstretched hand, 2 patients sustained injury due to RTA and one due to fall from height.

5 patients had poor results in our series (15.6%). 3 patients sustained injury due to RTA, one patient due to fall on outstretched hand and one due to fall from height. 4 out of these patients had Frykman type VII injury and one had type V.

Analyzing the results as per the age, revealed that 18 patients (56.2%) were below 40 years of age, of these 4 had excellent result (22.2%), 8 had good results (44.4%), 3 had fair and 3 had poor results. 14 patients were above 40 years of age of which 2 had excellent results (14.2%), 7 had good results (50%), 3 patients had fair results and 2 had poor results. This reveals that younger the patients better is the result. This may be due to better quality of the bone, high motivation to get back pre-injury status and better patient compliance.

In our series of 32 patients bone grafting was done in 6 patients. All were over 40 years of age. Of these none had excellent result, 3 had good results, 2 had fair result and one had poor result. This shows that the use of bone grafting may not have a bearing on the end result.

COMPLICATIONS:

The complications encountered in our study were as follows.

3 patients had deformity due to malunion, which put them into poor and fair category due to restriction of wrist movement and finger stiffness. One of them had bone grafting done. All were of 60 years and above.

7 patients had finger stiffness and 8 patients had restricted wrist movements and stiffness at wrist and fingers.

With increase in vehicular accidents, high energy fractures of distal radius are being more common. In our series we have used the buttress plate in treating comminuted intraarticular fractures of distal radius.

The results in our study show that excellent and good results were achieved in 65.6% i.e., in 21 patients and fair and poor results were seen in 34.3% i.e., in 11 patients. This means that the use of buttress plates gives relatively better results in comminuted intraarticular fractures of distal radius. This does not mean that buttress plating is the gold standard in the treatment of comminuted intra-articular fractures of distal radius. This is only an alternative method in treating these injuries. So we recommend buttress plating in comminuted intra-articular fractures of distal radius gives acceptable results.

Some of the advantages of buttress plating:

- Fracture fragments can be reduced under direct vision.
- Joint congruity can be maintained.
- Buttress plate provides stability and prevents collapse at the fracture site.
- Better patient compliance as the fixation is internal.
- Early mobilization can be achieved, thus reducing complication arising from cast immobilization.

SUMMARY

SUMMARY

Fractures of the lower end of radius involving the articular surface are mostly associated with high energy trauma. These injuries are associated with serious complications like malunion, radial shortening, post traumatic arthritis, delayed compression neuropathy, sudeck's osteodystrophy and shoulder hand syndrome. Early recognition, reconstruction of the articular surface with internal fixation enables the surgeon to mobilize the injured wrist at an early date. This prevents the complications from occurring.

In our study conducted between October 2010 to April 2012, 32 patients with fracture distal end of radius were managed by open reduction and internal fixation by buttress plate and screws. There were 53.1% males and 46.8% females and average age was 39.37 years. The commonest mechanism of injury was RTA i.e. 40.6%. The aim of the surgery was to buttress the severely comminuted fractures which allows for reconstruction of the lower end of radius and prevents dorsal or volar collapse of the fragments.

In our study we used Ellis-T buttress plates as buttressing device. The plates were secured to the bone with 3.5 mm cortical screws. Autogenous iliac bone graft was used whenever required.

The follow up period in our study ranged from 6-10 months. The patients were evaluated at 6 months follow up on the basis of demerit point system described by Gartland and Werley[9]. At the final follow up we had 18.7% of excellent result, 46.8% of good result, 18.7% of fair results and 15.6% of poor results.

Inability to reconstruct the articular fragments, severe comminution, poor quality of bone and poor patient's compliance lead to fair and poor results. The complications were: 3 patients had malunion and 8 patients had restricted wrist movements, stiffness and 7 patients had finger stiffness.

As per our results, excellent to good results were found in 65.6% of patients. So we conclude that this procedure is acceptable and it can be used as an alternative to other procedures in treating comminuted intra-articular fractures of distal radius.

CONCLUSION

CONCLUSION

- Road traffic accidents and fall on outstretched hand were the commonest mode of injury.
- Males were affected more than females.
- Younger the patients better the results.
- Excellent to good results were seen in 65.6% of patients by using buttress plate for fixation of fractures of distal end radius.
- Thus open reduction and internal fixation by buttress plate and screws can be an alternative to other procedures in treating the comminuted intra-articular fractures of distal end radius.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Jakim I, Pieter HS, Sweet MBE. External fixation for intraarticular fractures of distal radius. J Bone Joint Surg (Br).1991; 73:302-6.
2. Cooney WP. Fracture of distal radius, a modern treatment based classification Orthop Clin North Am 1993; 24:211-16.
3. Jupiter JB, Current concepts review fracture of distal end of radius, J Bone Joint Surg (Am) 1991; 292: 48-61.
4. Richrd A, Ro Gachferky MD, Lipson SR, Treatment of severely comminuted intraarticular fracture of distal end of radius by open reduction combined internal and external fixation. J Bone Joint Surg (Br) 2001; 83: 215-26.
5. Cooney WP, Linscheid RL, Dobyn JH. External pin fixation for unstable Colle's fracture. J Bone Joint Surg (A) 1979; 61:840-46.
6. Gerostathopoulos Nicolaos, Kalliakmanis Alkiviadis, Fandridis Emmanouil, Georgoulis Stylianos "Trimed Fixation system for Displaced fractures of the Distal Radius" Journal of Trauma, April 2007; vol.62.no.4: 913-918.
7. Crenshaw Andrew H, "Fractures of Shoulder, Arm, and Forearm", Chapter 54 in Campbell's operative Orthopaedics, Philadelphia: Mosby, Inc. 2003: 10th Ed. Vol 3 part xv: 3058-3066.
8. Chen Neal C and Jupiter Jesse B "Management of distal Radial Fractures", J Bone Joint Surg, 2007; 89: 2051-2062.
9. John J. Gartland, Charles W. Werley. Evaluation of healed colle's fractures. J Bone Joint Surg Am.1951; 33:895-907.

10. Robert W. Bucholz, James D Heckman: Rockwood Greens Fractures in Adults. 5th edition, Lippincott Williams & Wilkins 2001 Volume I: 815 – 867.
11. Neal C. Chen, Jupiter JB: Current Concepts Review, Management of Distal radial fractures. J Bone Joint Surg Am. 2007; 89:2051-62.
12. Ruch David S “Fractures of the distal Radius and Ulna”, Chapter 26 in Rockwood and Green’s Fractures in Adults, Philadelphia: Lippincott Williams & Wikins; 2006. 6thEd: 909-964.
13. Bholer L, Treatment of fractures, 4th ed. Baltmore: William wood. 1929.
14. Anderson R, O’Neil G. Comminuted fractures of distal end of radius. Surg gynecol obstet 1944; 78: 434-440.
15. Ellis J, Smith’s and Barton’s: A method of treatment. J Bone Joint Surg 1965; 47B: 724-727.
16. Bradway JK, Amadio PC, Cooney WP III. Open reduction and internal fixation of displaced, Comminuted intra-articular fractures of the distal end of the radius. J Bone Joint Surg 1989; 71A (6): 839-847.
17. Fitoussi F and Chow S P, “Treatment of displaced Intra articular fractures of the distal end of Radius with Plates”, J Bone Joint Surg (A) Sep.1997, vol.79-A no.9: 1303-1311.
18. Swan K, Capo JT, Tan V. Distal radius plating options. Curr Opin in Orthop 2003; 14(4): 238-244.
19. David Ring, Karl Prommersberger, Jesse B. Jupiter. Combined Dorsal and Volar Plate Fixation of Complex Fractures of the Distal Part of the Radius. J Bone Joint Surg Am.2005; 87:195-212.

20. Gruber G, Bernhardt G A, Kohler G, Gruberk. Surgical treatment of distal radial fracture with an angled fixed bar palmar plating system. Arch Orthop Trauma Surg.2006.

21. Ruch DS, Papadonikolakis A. volar verses dorsal plating in the management of intraarticular distal radius fracture. J Hand Surg Am.2006; 31:9-16.

22. Kamath A F, Zurakowski D, Day C S. Low profile dorsal plating for dorsally angulated distal radius fractures. J Hand Surg Am.2006; 31:1061-7.

23. Simic RM, Robison J, Gardner MJ, Gelberman RH, Weiland AJ, Boyer MI. Treatment of distal radius with dorsal plating system. J Hand Surg (Am) 2006; 31:382-386.

24. Rozental TD, Blazar PE. Functional outcome and complications after volar plating for dorsally displaced, unstable fractures of the distal radius. J Hand Surg (Am) 2006; 31:359-65.

25. Gerald Gruber, Max Zacherl, Christian Giessauf, Mathias Glehr, Fioretine fuerst et al .Quality of life after volar plate fixation of articular fractures of distal part of the radius, J Bone Joint Surg Am 2010;92:1170-1178.

26. Richard L D, Wayne Volg, Adam WM. Gray’s anatomy for students 686-689.

27. Berger RA, Gracia Elias M. General anatomy of the wrist. Chapter 1 in Biomechanics of the wrist joint. Springer-Verlag publication. 1991.

28. Palmer AK, Werner FW. The triangular fibrocartilage complex of the wrist – Anatomy and function. J Hand Surg. 1981; 6: 153-162.

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

30. Putnam MD, Seitz WH. Fractures of the distal radius. Chapter 20 in Rockwood and Green's Fractures in Adults. Edited by Bucholz RW, Heckman JD. Lippincott Williams & Wilkins Publication. 2001: 815-867.

31. Frykman G. Fracture of the Distal Radius Including Sequelae—Shoulder- Hand-Finger Syndrome, Disturbance in the Distal Radio-Ulnar Joint, and Impairment of Nerve Function: A Clinical and Experimental Study. Acta Orthop Scand. 1967; 108(Suppl):1–153.

32. Scheck M. Long term follow up of treatment of comminuted fractures of the distal end of the radius by transfixation with K-wires and cast. J. Bone Joint Surg. 1962; 44-A: 337-351.

33. Ark J, Jupiter JB. The rationale for precise management of distal radius fractures. Orthop Clin North Am. 1993 April; 24(2): 205-210.

34. Yamamoto K, Masaoka T, Shishido T, Imakiire A. Clinical results of external fixation for unstable Colle's fractures. Hand Surg. 2003; 8 (2): 193-200.

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

36. Fernandez DL. Fractures of the distal radius: Operative treatment. Instr Course Lect. 1993; 42: 73-88.

37. McMurtry, R.Y. and Jupiter, J.B.: Fractures of the Distal Radius. In: Skeletal Trauma, ed. Browner, B.D., Jupiter, J.B., Levine, A.M. and Trafton, P.G. Philadelphia, W.B. Saunders; 1992: 1063-1094.

38. Saffar P: Current Trends in Treatment and Classification of Distal Radial Fractures. In: Fractures of the Distal Radius, ed. Saffar, P. and Clooney, W.P.I., Philadelphia, J.B. Lippincott Company: 1995; 12-18.

39. Melone CP. Articular fractures of the distal Radius. Orthop Clin North Am. 1984; 15: 217-236.

40. Cooney W.P, Agee, J.M, Hastings, H.I, Melone, C.P.J and Rayhack J.M.: Management of Intraarticular Fractures of the Distal Radius. Contemp Ortho: 1990; 21:71-104.

41. Szabo RM. Extra articular fractures of the distal radius. Orthop Clin North Am. 1993 April; 24 (2): 229-237.

42. Lidstrom A. Fractures of the Distal End of the Radius: A Clinical and Statistical Study of End Results. Acta Orthop Scand. 1959; 41(Suppl): 1–118.

43. Muller, M.E., Nazarian, S. and Koch, P.: Classification AO des Factures. Paris, Springer Verlag, 1987.

44. Muller M.E, Nazarian S, Koch P and Schatzker J: The Comprehensive Classification of Fracture of Long Bones. Berlin, Springer Verlag, 1990.

45. Nana AD, Joshi A, Lichtman DM. Plating of the distal radius. J Am Acad Orthop Surg 2005; 13:159–71.

46. Hardy DH, Totty G, Renuis WR et al: Posterioanterior wrist radiography: Importance of arm positioning. J. Hand Surg.1987; 12A; 504.

47. Cassebaum W. Colle's fracture. A study of end results. JMJA 1950; 143:963.

48. Sarminto A, Zagorski JB, Sinclair WF. Functional bracing of colle's fractures. A prospective study of immobilization in supinaton Vs pronation. Clin Orthop 1980; 146: 175-183.
49. De palma AF; Comminuted fractures of distal radius treated by ulnar pinning. J Bone Joint Surg 1952; 43A: 651-662.
50. Green DP. Pins and plaster treatment of comminuted fracture of distal end of radius. J Bone Joint Surg 1975; 57A: 304-310.
51. Chapman DR, Bennet JB, Bryan WJ et al. Complication of distal radius fracture; Pins and plaster treatment. J Hand Surg 1982; 7A:509-517.
52. Weber SC, Szabor M. severely comminuted distal radial fracture as an unsolved problem; Complication associated with external fixation and pins and plaster techniques. J Hand Surg 1986; 11A: 157-165.
53. Lee BP, Tan CT. Comminuted Intra – articular fracture of the distal radius –results of early open reduction and internal fixation. Singapore Med J. 1992 Dec; 33(6); 612-5.
54. Alffram PA, Bauer GC. Epidemiology of fractures of the forearm: A biomechanical investigation of bone strength. J Bone Joint Surg Am 1962; 44:105-14.

ANNEXURES

<u>ANNEXURE I</u>

PROFORMA

<u>SHRI B.M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE, BIJAPUR – 586103.</u>

CASE NO :

NAME :

AGE/SEX :

I.P NO :

DATE OF ADMISSION :

DATE OF SURGERY :

DATE OF DISCHARGE :

OCCUPATION :

ADDRESS :

1) COMPLAINTS :
2) HISTORY OF PRESENT ILLNESS:
   a) Duration between the injury and first visit
   b) Symptoms – swelling
      pain
      loss of function
3) MODE OF INJURY :
4) GENERAL PHYSICAL EXAMINATION:
5) SYSTEMIC EXAMINATION :
6) LOCAL EXAMINATION:

INSPECTION	a) Attitude		
	b) Swelling		
	c) loss of function		
	d) Deformity		
PALPATION	a) local rise of temperature		
	b) Tenderness		
	c) Abnormal mobility		
	d) Crepitus		
MOVEMENTS		R	L
a) Wrist	- Flexion		
	- Extension		
	- Radial deviation		
	- Ulnar deviation		
b) Forearm	- Supination		
	- Pronation		
c) Elbow	- Flexion		
	- Extension		
d) Shoulder	- Abduction		
	- Adduction		
	- Flexion		
	- Extension		
	- Internal rotation		
	- External rotation		

			R	L
e) Fingers	-	Flexion		
	-	Extension		
	-	Abduction		
	-	Adduction		

7. DISTAL NEUROVASCULAR DEFECTS:

Neurological	-	Ulnar nerve	
	-	Median nerve	
	-	Radial nerve	
Vascular	-	Distal pulses	

MANAGEMENT:

INVESTIGATIONS:

X-RAY OF WRIST: ANTEROPOSTERIOR AND LATERAL VIEW.

BLOOD:	Hb%:-	TC:-	DC:-
	ESR:-	Blood grouping Rh typing:-	
URINE	Albumin	Sugar	

BLOOD SUGAR RANDOM : - BLOOD UREA:-

SERUM CREATININE:-

ECG in elderly:-

TREATMENT:

FOLLOW-UP:

ANNEXURE II

CONSENT FORM

SHRI B.M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE, BIJAPUR – 586103.

TITLE OF STUDY: EVALUATION OF MANAGEMENT OF FRACTURE OF DISTAL END OF RADIUS IN ADULTS TREATED BY OPEN REDUCTION AND INTERNAL FIXATION BY PLATE AND SCREWS.

Principle Investigator	:	DR.SHUSHRUT B BHAVI
P.G. Guide Name	:	DR. O. B. PATTANASHETTY M.S (ORTHO)

All aspects of this consent form are explained to the patient in the language understood by him/her.

I) INFORMED PART

i. Purpose of study

I have been informed that this study will test the effectiveness of one particular method of open reduction and internal fixation in fracture of distal end of radius. This method requires hospitalization.

ii. Procedure

I will be selected for the treatment after the clinical study of my age, type of fracture, condition of bone seen in radiograph and after study of fitness for anaesthesia and surgery .I will be admitted immediately. I will have to attend follow-up to OPD regularly. I will be assessed in physiotherapy department also.

iii. Risk and Discomfort

I understand that I may experience some pain and discomfort during the post operative period. This condition is usually expected. These are associated with the usual course of treatment

iv. Benefits

I understand that my participation in this study will have no direct benefit to me other than the potential benefit of treatment which is planned to heal my fracture in the shortest possible period and restore my function.

v. Alternatives

I understand that, the various alternative modes of treatment available to me in this fracture pattern with their merits and demerits have been explained to me.

vi. Confidentiality

I have been assured that all information furnished to the doctor by me regarding my medical condition will be kept confidential at all times and all circumstances except legal matters.

vii. Requires for more information

It has been made clear to me that I am free at all time under any circumstances to touch based with doctor by directly approaching or otherwise to satisfy any query , doubt regarding any aspect of research concerns.

viii. Refusal or withdrawal of participation

It has been made clear to me that participation in this medical research is solely the matter of my will and also that right to withdraw from participation in due course research at any time.

II) CONSENT BY PATIENT

I undersigned, have been explained by Dr Shushrut B Bhavi in the language understood by me. The purpose of research, the details or procedure that will be implemented on me. The possible risks and discomforts of surgery and anaesthesia have been understood by me. I have also been explained that participation in this medical research is solely the matter of my will and also that I have the right to withdraw from this participation at any time in due course of the medical research.

Signature of participant/patient date: time:

Signature of witness: date: time:

ANNEXURE III

MASTER CHART

KEY TO MASTER CHART:

SL.NO	-	Serial Number
IP.NO	-	In Patient Number
R	-	Right side
L	-	Left side
MOI	-	Mode of Injury
RTA	-	Road traffic accident
FOOH	-	Fall on outstretched hand
FFH	-	Fall from height
D.Injury	-	Direct Injury
LOF	-	Length of Follow up
Rest. Wrist move	-	Restricted wrist movements

MASTER CHART

SL.NO	NAME	AGE	SEX	IP.NO	SIDE INVOLVED	MOI	FRYKMAN TYPE	SURGICAL APPROACH	BONE GRAFTING	LOF In Months	COMPLICATIONS	RESUTLS
1	Siddarayya	21	M	1569	L	FFH	III	Volar	No	8	Nil	EXCELLENT
2	Amruta	22	F	24800	R	D.Inj	III	Volar	No	6	Nil	GOOD
3	Kallappa	60	M	24055	R	FOOH	VII	Volar	Yes	9	Rest. Wrist Move, Finger Stiffness	FAIR
4	Devendra	53	M	2166	R	FFH	III	Volar	No	10	Finger Stiffness	GOOD
5	Devakar Rathod	35	M	2127	R	RTA	VIII	Volar	No	7	Finger Stiffness	FAIR
6	Gurulingawwa Biraddar	65	F	39280	R	FOOH	V	Volar	Yes	6	Malunion, Rest. Wrist Move, Finger stiffness	FAIR
7	Priyanka Patil	25	F	66942	R	D.Inj	III	Volar	No	7	Nil	GOOD
8	Rekha Patil	26	F	5374	L	RTA	V	Dorsal	No	6	Nil	GOOD
9	Chanappa	28	M	5958	R	RTA	VII	Volar	No	9	Nil	EXCELLENT
10	Shivagangamma	62	F	6327	L	FOOH	III	Volar	No	6	Nil	GOOD
11	Anil	26	M	7441	R	RTA	VII	Volar	No	8	Nil	EXCELLENT
12	Shankramma	61	F	8783	R	FOOH	III	Dorsal	Yes	6	Finger Stiffness	GOOD
13	Praveen	36	M	127818	L	D.Inj	I	Volar	No	10	Finger Stiffness	GOOD
14	Ravi Kumar Patil	35	M	12013	L	RTA	VII	Volar	No	8	Rest. Wrist Move	POOR
15	Kasturi	50	F	229172	R	FFH	V	Volar	No	7	Nil	GOOD
16	Raju	30	M	17905	R	RTA	VI	Volar	No	6	Nil	GOOD
17	Meerabai	51	F	21932	R	FFH	I	Volar	No	7	Nil	GOOD
18	Radhabai	69	F	22655	R	FOOH	III	Volar	No	6	Malunion, Rest. Wrist Move, Finger stiffness	FAIR
19	Gourawwa	45	F	21828	R	D.Inj	V	Volar	Yes	8	Nil	GOOD
20	Vishnu. V	60	M	25410	L	FOOH	VII	Dorsal	No	8	Malunion, Rest. Wrist Move, Stiffness	POOR
21	Amarappa	44	M	4197	R	RTA	III	Volar	No	9	Nil	EXCELLENT
22	Priyanka	28	F	26759	L	RTA	V	Volar	No	6	Finger Stiffness	GOOD
23	Hanmantappa	41	M	1003	R	FFH	VI	Volar	Yes	7	Finger Stiffness	GOOD
24	Kashibai Patil	40	F	2552	L	FOOH	III	Volar	No	6	Nil	EXCELLENT
25	Kanta Hiremath	30	F	3399	R	FFH	V	Volar	No	6	Rest. Wrist Move, Stiffness	POOR
26	Santosh.G.Patil	24	M	4644	R	RTA	VII	Volar	No	7	Rest. Wrist Move, Stiffness	POOR
27	Rajshekar Hiremath	29	M	5445	R	RTA	VII	Dorsal	No	6	Finger Stiffness	GOOD
28	Mohan Pattar	28	M	5616	R	RTA	III	Volar	No	6	Rest. Wrist Move	GOOD
29	Fatima Mulla	25	F	7033	R	FFH	III	Volar	No	6	Rest. Wrist Move, Stiffness	FAIR
30	Subhas Thakur	30	M	7825	L	RTA	VII	Dorsal	No	6	Rest. Wrist Move, Stiffness	FAIR
31	Sharadabai	36	F	6937	R	FOOH	III	Volar	No	6	Nil	EXCELLENT
32	Anand.S.M	45	M	7030	R	RTA	VII	Volar	Yes	6	Rest. Wrist Move, Stiffness	POOR