

Clinicoradiological Outcome of Intra Articular Distal End Radius Fracture with Volar Locking Plates

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Abstract: Introduction: The most common trauma mechanism is falling over the outstretched hand. The desire for anatomical restoration of the distal radial joint is the rationale for operative treatment. Distal end radius fracture is frequently comminuted & this is responsible for slipping of the reduction, which is a rather common late feature. Open reduction and internal fixation is indicated to address the unstable distal radius fractures and those with articular incongruity that cannot be anatomically reduced & maintained through external manipulation and ligamentotaxis alone. Methodology: 60 indoor patients, befitting the inclusion criteria, who have consecutively consented for the study and undergone ORIF of fractures of the DRFs using locking compression plates through a volar approach at Nanavati Hospital, Mumbai between June 2014 and Feb 2016 were assessed & followed up at serial intervals. The evaluation of clinicoradiological outcomes of these patients was done at follow up using the Demerit Point scoring system of Gartland and Werley with Sarmiento Modification. Results: The study comprised of 60 subjects, 28 male & 32 females, between the ages of 25 and 82 years who suffered intra-articular DRFs and managed operatively – ORIF using volar LCP at our hospital. Average time to surgery from time of injury was 1.75 days. Patients were asked to follow up routinely, with post operative follow up ranging from 12 weeks to 18 months. Scoring System results obtained were as follows: 63% patients – Excellent, 32% patients – Good, 5% patients – Fair, 0% patients – Poor. Conclusion: Intra-articular DRFs represent a therapeutic challenge as compared with unstable extra-articular fractures. With the recent development of specifically designed locking implants for the distal radius, fragment-specific fixation has emerged as an option. ORIF using volar locking compression plates has shown to be a valid treatment option for unstable, Displaced & distal radius intra articular fracture.

Keywords: distal radius fractures, articular disruption, open reduction internal fixation; ligamentotaxis, fragment specific fixation, locking compression plate, volar approach, intra-articular

1. Introduction

Distal radius fractures have been a common affliction for millennia, but their treatment is a more recent development as a result of human erudition. While immobilization has served as the only available treatment for most of our history, many advances have been made in the management of distal radius fractures over the last century as the field of orthopedics has grown. Today, we have a better understanding of radiocarpal anatomy, wrist biomechanics and bone physiology than ever before, and we continuously strive to refine our surgical techniques to optimize outcomes.

In 1814, Abraham Colles published his landmark treatise on DRF that led to his eponymous reward. In “On the fracture of the carpal extremity of the radius”, Colles calls to question those who describe all wrist injuries as dislocations, and offers an explanation to why this may have been so³. He also describes how to reduce the injury and notes the importance of immobilization with a wooden splint to prevent the wrist from falling into dorsal displacement. However, it was the work of Guillaume Dupuytren that brought these fractures to the interest of the surgical world at large.⁴

The advent of roentgenography marked a significant milestone in the evaluation and management of fractures. For the first time, physicians were able to discuss fractures on the basis of degree of displacement and articular involvement in the live patient, rather than the autopsy specimen. The conservative management of DRFs would be called into question for the first time. Several authors began publishing on the radiographic findings of DRFs soon

afterwards in the late 19th and early 20th centuries.⁵⁻⁹ They called into question the results that had previously been thought adequate and started postulating how to address their concerns. Throughout this era however, management of DRFs remained predominantly nonoperative.

Albin Lambotte was the first to attempt controlling the fragments in a DRF by surgical means. In 1908, he described the use of a percutaneously placed wire through the radial styloid to maintain reduction.¹⁰ However, it took more than 40 years before a case series with results using K-wires was published in the literature¹⁰.

With the dissemination of Lister's advances in antisepsis, surgical management was becoming a safer option, and internal fixation had its first vocal and effective advocates in the early 20th century with men like Sir Arbuthnot Lane and Albin Lambotte. Lane and Lambotte began to treat fresh closed fractures with internal fixation, thus developing the early principles of osteosynthesis.¹¹⁻¹⁴ Each operative technique has had its proponents over the last several decades – surgeons who innovated surgical procedures to improve their results, as well as the manufacturers who have improved implant design and materials. However, the use of internal fixation in DRF has probably seen the greatest change in interest and largest increase in operative options over the past 2 decades. With a better understanding of DRF fracture patterns and wrist biomechanics, a multitude of implant systems with a wide variety of designs have been developed. Over the last decade, volar locking compression plates have taken hold as the implant of choice, and operative fixation of DRF is at an all time high.¹⁵ Aim of the study is to analyze the functional and clinico-

radiological outcome of intra-articular fractures of distal end of radius managed operatively using open reduction and internal fixation with locking compression plates through volar approach, evaluated using the Demerit Point Scoring System of Gartland & Werley, modified by Sarmiento *et al.*

2. Materials and Methods

60 indoor patients, fitting within the inclusion criteria, who have consecutively consented for the study, who have undergone open reduction and internal fixation with volar locking plates for intra-articular fracture of distal end of radius at Dr. Balabhai Nanavati Hospital, Mumbai, between April 2014 to Feb 2016. On admission, detailed examination after hemodynamic stabilization of patient was carried out and then standard posteroanterior and lateral views of distal end radius were taken and were classified according to AO classification. Prior ethical committee approval Taken before study.

Inclusion Criteria

- Adults (aged over 18years), both male and female with intra-articular fractures of distal end radius.
- Patients willing for treatment and given-informed written consent.

Exclusion Criteria:

- Patients <18 years of age
- Patients lost to follow up.
- Patients medically unfit for surgery
- Open fractures
- Previous distal radial fracture on the affected side
- Bilateral distal radial fracture
- Neurovascular injuries
- Associated musculoskeletal injuries to same arm.
- Patients with extra-articular fractures of distal end of radius (AO Type A)
- Patients not willing OR not consenting for operative management.

They were assessed and followed up at 1.5 months, 3 months and 6 months each from the date of surgery (minimum range of follow up between 6 to 18 months). Data was collected using interviews and observation of clinical findings. The subjective, objective and radiological outcomes of these patients were done using the Demerit scoring system of Gartland and Werley and Sarmiento scoring system

Surgical technique:

Under tourniquet control, under prophylactic cover of intravenous Cefazidime & Amikacin/ Ciplox (for those with deranged renal function), The incision for volar fixation of the distal radius is typically performed through the distal extent of the Henry approach (the modified Henry's approach), under adequate anaesthesia. An incision is made between the flexor carpi radialis (FCR) tendon and the radial artery. This interval is developed, revealing the flexor pollicis longus (FPL) muscle at the proximal extent of the wound and the pronator quadratus muscle more distally. The radial artery is carefully retracted radially, while the tendons of the FCR and FPL are retracted ulnarly.

The pronator quadratus is divided at its most radial aspect, leaving a small cuff of muscle for later reattachment. Any elevation of the muscle of the FPL should be performed at its most radial aspect, as it receives its innervation from the anterior interosseous nerve on its ulnar side. After the pronator quadratus has been divided and elevated, the fracture is readily visualized, and reduction maneuvers can be accomplished under direct vision.

After exposure and debridement of the fracture site, the fracture is reduced and provisionally fixed under fluoroscopy with K-wires, reduction forceps or suture fixation. Reduction Aids should be placed so as not to interfere with placement of the plate.

The appropriate plate is selected following fracture reduction.

First, a standard cortical screw was applied to the most distal oval hole of the vertical limb of the plate in order to temporarily secure the plate to the proximal fragment. This allowed concomitant proximal and distal plate adjustment. After fixing the distal fragment with subchondral locking screws, radial length was gained, when necessary, by pushing the plate distally. The first standard screw can be either left in situ or exchanged with another locking screw; the oval hole is a combination hole designed for locking head screw placement at the distal end and standard screw placement at the proximal end of the same hole.

The optimal placement of the distal screws is important: they must be inserted at the radial styloid, beneath the lunate facet, and near the sigmoid notch. The distal screws can be of either monocortical or bicortical engagement. More volar tilt can be achieved during distal screw placement when the wrist is volarly flexed as much as possible by an assistant. Moreover, radial length can be further improved by pushing the whole plating system distally while using the oval plate hole and screw as a glide. The final position of the plate was confirmed using fluoroscopy. Pronator quadratus muscle was used at the time of closure, to cover, in part, the implants that were applied to the anterior surface of the radius.

Once stable fixation was achieved and hemostasis secured, wound was thoroughly washed with NS, closed in layers and sterile compression dressing was applied. The tourniquet was removed and capillary refilling was checked in the fingers. The operated limb was supported with a dorsal below elbow POP slab with the wrist in neutral position until suture removal after weeks. Following admission to the hospital, a careful history was elicited from the patients and / or attendants to reveal the mechanism of injury and the severity of trauma. All patients were thoroughly examined. Their general condition associated systemic diseases and associated injuries were noted. All the findings were duly recorded in the patient proforma.

Careful inspection of the deformity, swelling and ecchymosis were done. Clinically tenderness, bony irregularity, crepitus and the relative position of radial and ulnar styloid process were elicited. Movements of the wrist and forearm were checked and found to be painful and limited. Distal vascularity was assessed by radial artery

pulsations, capillary filling, pallor and paraesthesia over finger tips.

The involved forearm was immobilized in a below elbow POP slab and kept elevated, in an arm-pouch sling whenever possible. Pain and inflammation were managed using analgesics in adequate doses at frequent intervals



Operative Photographs



LCP with guide Sleeve



Volar Distal Radius LCP

Intraoperative Images



Patient Position



USG guided Axillary Block



Pneumatic Tourniquet



Painting of Surgical Site



Position of C-arm



Post Operative Protocol

Week 1

- a) Splint placed in OT on full-time
- b) Finger ROM
- c) Physio to start week 2

Week 2-4

- a) Remove splint & place limb in crepe bandage.
- b) Modalities as needed for pain, but should be minimal
- c) Crepe Bandage may be removed 3 times per day for exercises, plus bathing
- d) Exercises consist of:
 - Finger full ROM
 - Thumb opposition
 - Wrist ROM flexion / extension / pronation / supination / painter's (dart-throwing) motion
 - Elbow AROM
 - No PROM wrist
 - PROM fingers / thumb if needed after 1 week

Week 4-8

Goal is to recover wrist motion and grip strength

- a) Continue week 2-4 as indicated by lack of progress as

fingers / thumb should have full ROM and wrist should be at least 30 / 30 flex / ext

- b) Light PROM to improve wrist ROM
- c) Early grip strengthening
- d) Scar massage / desensitization may rarely be needed

Week 8-12

- a) In the unusual case of poor progress with ROM (flexion <40°, extension <30° at end of week 6, initiate exercises 3x/day:
 - Prayer, pushing on table or wall
 - Reverse prayer, flexion over side of table
 - Painter's motion
 - Pronation usually not needed as it recovers naturally pretty well. If lacking, aggressively work this as it is very important.
 - Supination (hammer, under-hand thenar grab by patient with other hand)
 - Finger / thumb patient assisted passive flexion as needed
- b) Grip strengthening without restriction
- c) Dynamic splinting after week 12, if less than 40° flexion and 30° extension.

Evaluation of Outcome

The patients were followed up regularly and clinical, radiological and functional reviews were performed at periodic intervals.

Clinical and Functional

Functional evaluation of the patients was done at the last follow up according to the **demerit point system of Gartland and Werley¹⁶** with Sarmiento et al's modification.

3. Results

The present study consists of 60 cases of intra-articular distal radius fractures treated surgically using volar LCP at Dr Balabhai Nanavati Hospital, Mumbai, Maharashtra between June 2014 to Feb 2016. All cases were followed up regularly during the period between 2014 to 2016. Patients were asked to follow up at 2 weeks following surgery for removal of sutures. Subsequent follow ups were done at 6 weeks, 3 months, 6 months and 12 months upto 18 months following surgery. The following are the observations made to the available data analysed as follows.

- The majority of the patients were from the age group of 51-60 years which accounts for 23.3% of patients in our study. The youngest patient was 25 years of age and the oldest patient was 82 years of age. The mean age was 55.3 years.
- There was a female preponderance in the ratio of 1.14:1 accounting for 53% of the total number of patients in this study.
- The majority of our patients (36 patients, 60%) came with an alleged history of fall on outstretched hand followed by history of road traffic accident (24 patients, 40%)
- There was a predominance of right side over left with 44 (73%) patients presenting with injury to the right wrist. The dominant side was found to be involved in 46 (77%) out of 60 patients in our series, resulting in limitation of activities of daily living.
- As per the AO/ASIF classification, 34 (57%) patients had a Type 23C2 fracture. The next most common type was the 23B3 type of fracture with 13 (22%).

AO Type	CASES
B1	1
B2	3
B3	13
C1	5
C2	34
C3	4

- 29 (48%) patients in the study did not suffer from any medical co morbidities. 31 patients had some associated medical condition ranging from hypertension to diabetes mellitus to hypothyroidism to ischaemic heart disease. one patient was found to have psoriasis with inactive lesions.
- All cases in the present study underwent surgery within 6 days from the time of injury, at an average of 1.75 days. 9 patients had other associated fractures, mostly resulting from high-energy trauma in an RTA viz fracture shaft of

femur, intertrochanteric fracture of femur, multiple rib fractures, humerus shaft fracture, acetabulum fracture, superior pubic ramus fracture, patella fracture, clavicle fracture and a calcaneum fracture. 4 patients who presented with a distal radius fracture resulting from fall were also seen to have associated fractures of the superior pubic ramus, an intertrochanteric fracture of the femur, a femur neck fracture and a contralateral shoulder dislocation. The delay in surgery, if it occurred in these cases was in order to stabilise the associated, more grievous injury and the general condition of the patient to optimise surgical fitness.

- The patients were asked to rate their perception of the condition of the operated wrist in terms of pain, disability and limitation of motion at final follow up . 40 (67%) of the patients rated their condition as Excellent, 17 (28%) as Good while 3 (5%) rated theirs as Fair.
- Only 1 (2%) patient presented post operatively with a persistent deformity –residual dorsal tilt, most likely occurring due to loss of reduction. No other residual deformity was seen in any other patient at final follow up.
- At final follow-up all patients had achieved full finger range of motion. The mean wrist motion was as follows: 64.33° of dorsiflexion (normal range, 60-85°), 68.67° of palmarflexion (normal range, 60-80°), 23.75° of ulnar deviation (normal range, 20- 40°), 17.75° of radial deviation (range, 10-20°), 73.3° of pronation (normal range, 60- 90°), and 77.5° of supination (normal range, 60-90°). 2 (3%) patients complained of loss of grip strength more than 60% as compared to contralateral wrist.

Movement	Cases	Percentage
Dorsiflexion (>45°)	60	100%
Palmarflexion (>30°)	60	100%
Supination (>50°)	60	100%
Pronation (>50°)	60	100%
Radial Deviation (>15°)	56	93%
Ulnar Deviation (>15°)	60	100%
Significant Loss Of Grip Strenth (>60%)	2	3%

- 4 (7%) of the patients in our series experienced varying degrees of joint stiffness, while 2 (3%) had paraesthesias in the distribution of the radial nerve. There were no cases of complex regional pain syndrome (CRPS). There was no case of infection or implant failure. No flexor or extensor tendon injuries were noted at final follow up. No median nerve complications were seen.

Complications	Cases	Percentage
Joint stiffness	4	7%
Paraesthesia (in radial nerve distribution)	2	3%
Complex Regional Pain Syndrome	0	0
Hardware Related	0	0
Wound Site Infections	0	0
Median Nerve Complications	0	0
Tendon Irritation	0	0

- All 60 cases showed signs of radiographic union at an average of 12.8 weeks (range 10-16 weeks) with about 37 (62%) of the cases showing bony union at 12 weeks.
- At final follow-up, the average volar tilt was 4.5° (range,

5° of dorsal tilt to 9° of volar tilt), radial inclination averaged 20.2° (range, 16-23°), radial shortening averaged 1.17 mm (range, 0-3 mm), and articular congruity averaged 0.33 mm (range, 0-2 mm).

- The radiological score according to the Sarmiento modification of Lidström & Frykman criteria was Excellent in 52(87%) patients, Good in 7(12%) patients and fair in 1(1%) patient.

Radiological Score	Cases	Percentage
Excellent	52	87%
Good	7	12%
Fair	1	1%
Poor	0	0%

- Of the 60 patients in our series, in accordance with the Demerit Scoring System of Gartland & Werley, 38 (63%) patients had an Excellent functional outcome at final follow up, 19 (32%) had a Good outcome while 3 (5%) patients had a Fair outcome. No patients who participated in our study were seen to have had a Poor functional outcome

Result	Cases	Percentage
Excellent	38	63%
Good	19	32%
Fair	3	5%
Poor	0	0%

4. Discussion

The treatment goal for fractures of the distal end of the radius is fully functional recovery of the wrist and prerequisites are restoration of the anatomy and early mobilization. Extra-articular fractures give better results than intra-articular fractures. Functional outcome depends upon patient's age, fracture anatomy, displacement, reducibility, stability and articular incongruity of fractures. It has also been shown that functional results are related more to the quality of anatomical reduction than to the method of immobilization. Volar locking compression plating is a safe and effective treatment for unstable fractures of the distal radius. It can also stabilize dorsally unstable distal radius fractures with least complications. Specially locking implants provide advantages in the treatment of distal radius fractures with metaphyseal comminuted zones (C2 and C3 fractures).

An advantage of volar plating technique is the comfort that it provides to patient in initiating early finger & wrist motion. Despite, our use of an early motion rehabilitation protocol, the distal end radius fracture reduction was maintained at the follow-up periods. Early rehabilitation had the additional advantage of enabling the patient to regain independence in daily activities rather quickly.

The present study was undertaken to assess the functional outcome of operative management of distal radial fractures using a volar locked compression plate.

In our study, distal radial fracture was more common in the 6th to 8th decade with an average of 55.3 years which is comparable to study published by R.E. Anakwe¹⁷ stating

that the mean age is 48 years.

Our series had a female preponderance with 32 female patients as compared to 28 male patients and is comparable to previous studies in literature published by Ayhan kilic¹⁸⁸. This indicates women are more osteoporotic than men.

In our series 40% of the patients had suffered the fracture in a road traffic accident while 60% of patients suffered the fracture due to a fall on outstretched hand

The right side, (dominant side in most cases in our series) was involved in 44 of the cases in the present study as opposed to only 16 cases with left sided involvement.

In our series, out of 60 patients with intra-articular distal radius fractures i.e AO Type B and/or C, 1 patient had a 23B1 fracture, 3 patients had a 23B2 fracture, and 13 had a 23B3 fracture type. 5 patients suffered a 23C1 fracture type, 34 suffered a 23C2 fracture type while 4 had a 23C3 fracture type which is comparable to study by Ayhan kilic¹⁸

Out of the 60 patients in our series, 4 (7%) developed joint stiffness as a late complication post operatively. 2 (3%) patients complained of paraesthesia in the distribution of the radial nerve. This accounts for a complication rate of 10% which is comparable to study done by Kevin Chung¹⁹ and sahu et al.²⁰

In our series of 60 patients who suffered intra-articular distal radius fractures and underwent surgical reduction & fixation with volar locking compression plates, 38 (63%) patients had an Excellent outcome, 19(32%) had a Good outcome, 3(5%) had a Fair outcome while none had Poor outcome, as evaluated using Demerit Scoring System of Gartland & Werley.

These findings are fairly consistent with previous studies in literature, evaluating functional outcome of surgically managed intra-articular distal radius fractures using volar locking systems.

Drobtz and Kutscha-Lissberg (2003)²¹ in their series of 50 patients had 26(52%) Excellent results, 20(40%) Good results, 3(6%) Fair results and 1(2%) Poor results.

Kamano et al (2005)²² studied 40 patients of intra-articular DRFs treated using volar LCPs and had 12(30%) Excellent results and 28(70%) Good results.

Osada et al (2008)²³ in a study of 49 patients, found 47 (96%) cases had an Excellent result and 2(4%) cases had a Good outcome.

In a study by **Matschke et al (2011)**²⁴ of 117 patients, 59 (50%) had an Excellent Result, 37(32%) had a Good result, 12(10%) had a Fair result while 9 (8%) patients had a Poor result.

The most cited paper in the relevant literature is by Knirk and Jupiter (Knirk and Jupiter, 1986), investigating the outcome of intra-articular distal radius fractures in young adults at an average 6.7year follow-up. The authors found

that 65% of their population developed radiographic evidence of osteoarthritis and 39% had a poor or fair result. They inferred that one was the result of the other. They concluded that accurate articular restoration was the most critical factor in achieving a successful result.

At final follow up



Figure 33.3: Palmarflexion & Dorsiflexion



Figure 33.4: Radial & Ulnar Deviation



Figure 33.5: Supination & Pronation

5. Conclusion

Fracture of the distal end radius constitutes one of the most common skeletal injuries treated by the orthopedic surgeon and constitutes 17% of all the fractures and 75% of all forearm fractures. Various treatment options are available for fracture distal end of radius ranging from closed reduction cast application to percutaneous pinning to interlocking nails and even hemiarthroplasty of the distal radius as open reduction and volar plating ensures more consistent correction of displacement and maintenance of reduction, the volar locked plate osteosynthesis is slowly being considered by most in the field as the “gold standard” in treatment of unstable distal radius fractures.

An advantage of volar plating technique is the comfort that it

provides to patient in initiating early finger & wrist motion. Despite, our use of an early motion rehabilitation protocol, the distal end radius fracture reduction was maintained at the follow- up periods. Early rehabilitation had the additional advantage of enabling the patient to regain independence in daily activities rather quickly. The expectation of a speedier recovery and potential earlier return to work has been one of the driving forces for the increasing use of volar locking plate fixation in an active, younger population.

A major chunk of the patients in the present series was in the 6th decade of life. Also, there were more females than males in our study, most of them belonging to the postmenopausal age group suggesting osteoporosis likely contributes to the epidemiology of distal radius fractures in the elderly population. Primarily weakening metaphyseal bone, osteoporosis renders simple fractures unstable and makes distal bone fixation a challenge. The volar locking plate is a stiff construct which provides solid support for the joint surface even in osteoporotic bone and allows simple subchondral placement of screws with sustained retention of the outcome of reduction. Secondary loss of anatomical correction can be avoided by this procedure. Since the earliest descriptions of fractures of the distal radius, the assumption has been made that a good result will be achieved whatever the appearance of the reduction. This may still be the case in most fractures which occur in elderly, low-demand patients, but there is a clear distinction between this group and those with higher demand which may not necessarily be young. In the Indian scenario however, financial considerations sometimes preclude the use of plate osteosynthesis for the management of intra-articular distal radius fractures and the surgeon is forced into choosing another surgical/non-surgical alternative. However, for those patients in an urban setup with a variety of options at their disposal, the use of ORIF with a volar locking plate resulted in stable fixation of the distal articular fragments, allowing early postsurgical wrist motion with fewer complications and good to excellent functional and clinico-radiological results in the short & medium term as compared to other methods of management of intra-articular distal radius fractures.

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