

PROSPECTIVE STUDY ON SHORT-TERM ANALYSIS OF CLINICAL, RADIOLOGICAL AND FUNCTIONAL OUTCOME OF SURGICAL MANAGEMENT OF TYPE B & TYPE C DISTAL RADIUS FRACTURE WITH VOLAR LOCKING PLATE

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Abstract

Background: Distal radius fractures are common, bimodal injuries that can occur in young and old patients. Treatment goals include anatomic reduction, joint stability, and early mobilisation. Surgical fixation with volar locking plates is the gold standard for most fractures. This study analysed the short-term clinical, radiological, and functional outcomes of surgical management of type B and type C distal radius fractures with volar locking plates. **Materials and Methods:** This prospective study was conducted at the Institute of Orthopaedics and Traumatology, Madras Medical College and Rajiv Gandhi Government General Hospital between May 2011 and November 2013. Twenty-eight consecutive intraarticular distal radius fractures in skeletally matured patients were managed primarily by internal fixation with a Locking compression plate whose screws were multidirectional. **Result:** Good bony union was achieved in all patients, with an average time to union of 12 weeks. There was a low rate of complications, including malunion (3%) and nonunion (9%). The majority of patients (84%) had excellent radiological outcomes. The mean range of motion was good, with palmar flexion of 75 degrees, dorsiflexion of 60 degrees, supination of 70 degrees, pronation of 65 degrees, ulnar deviation of 20 degrees, and radial deviation of 15 degrees. Grip strength was, on average, 80% of the opposite normal side. There were no cases of iatrogenic neurovascular injury, implant breakage, or tendon rupture. **Conclusion:** The study suggests that early primary fixation with a fixed-angle volar locking plate is a safe and effective treatment for distal radius fractures.

INTRODUCTION

Distal Radius fractures have a Bimodal age distribution, one with a younger age group who sustained injury due to high-energy trauma and another group of elderly patients with relatively low-energy trauma.^[1,2] Due to its high energy association, most distal radius fractures are now associated with other long bone fractures. So much importance is given to treating long bone fracture fixation and neglecting distal radius fracture, which results in poor functional outcomes.^[3,4]

The importance of fixation of distal radius fractures evolved over the past two decades from the century-old treatment of cast immobilisation through Kirschner wire fixation to internal fixation with various plates. Tremendous improvement in the functional outcome of the wrist had been observed following the fixation of intraarticular fractures with

diverse available volar locking plates and in surgical technique leading to less disfigurement. Most of the distal radius fractures will fall into their anatomical position if good anatomical reduction of the distal radius is achieved by definitive internal fixation.^[5,6] The goals of treating distal radius fractures are to restore joint line congruity, joint stability and alignment with minimal soft tissue dissection to allow for early mobilisation and establishment of good function. Still, this early mobilisation can be started only after stable internal fixation and not by mere K wire fixation. Some studies have revealed that even after better fixation of distal radius fractures alone when a medial column is not addressed resulted in distal radioulnar joint instability and hence poor functional outcome in later years.^[7-9]

Good functional results were reported with either modality in low-energy fractures in older people.

However, the ideal treatment for high-energy injuries with comminuted distal radius fractures is still being debated. This justifies a separate review of the internal fixation of distal radius fractures. This study analysed the short-term clinical, radiological, and functional outcomes of surgical management of type B and type C distal radius fractures with volar locking plates.

MATERIALS AND METHODS

This prospective study was conducted at the Institute of Orthopaedics and Traumatology, Madras Medical College and Rajiv Gandhi Government General Hospital between May 2011 and November 2013.

Twenty-eight consecutive intraarticular distal radius fractures in skeletally matured patients were managed primarily by internal fixation with a Locking compression plate whose screws were multidirectional.

Inclusion Criteria

Patients who were above 18 years old with AO type B and type C Distal Radius intraarticular fracture associated with or without ulnar styloid fracture, closed type B & C distal radius fractures, and intraarticular distal radius fracture with either volar or dorsal displacement were included.

Exclusion Criteria

Patients under 18 years old with undisplaced extra-articular radial fractures, open fractures, severe osteoporosis with limited functional capacities, and medical co-morbidities were excluded.

Patients of both sexes were recruited in the study according to the devised inclusion and exclusion criteria. All patients provided written informed consent before they participated in the study.

Radiological Evaluation: Standard posteroanterior and lateral views of the wrist are taken to assess the fracture pattern and parameters. Oblique views may also be taken. The fracture pattern is evaluated as palmar tilt, radial length, radial inclination, fracture displacement, scapholunate angle, radioulnar index, intra-articular step-off, ulnar angulation, volar angulation, grade of osteoarthritis, and involvement of radiocarpal and distal radioulnar joints.

Computed Tomography: CT scans can best assess articular surface depression, comminution, and displacement. In cases with suspicion of severe comminution and displacements, CT of the wrist with 3D reconstruction may be done.

There are several classification systems for distal radius fractures. Frykman classification: This system defines the fracture as intra-articular or extra-articular and describes the involvement of radiocarpal and distal radioulnar joints along with the presence or absence of ulnar styloid process fracture. It does not quantitatively assess the degree of comminution, shortening, and initial impact.

Fernandez Classification: This system is based on the mechanism of injury and addresses the potential

for ligamentous injury. The fracture pattern is classified into five types.

AO Classification: This system is based on the location of the fracture and the degree of articular involvement. There are three types of fractures: extra-articular, partial articular, and complete articular.

Modified AO Classification: The AO classification for distal radius fractures was modified to include five intra-articular fracture types: Type A: Extra-articular, Type B1: Radial styloid fracture, Type B2: Dorsal rim fracture, Type B3: Volar rim fracture, Type B4: Die-punch fracture, and Type C: Complete articular.

Preoperative Workup: The limb was stabilised in an above-elbow splint, and routine investigations were performed. The fracture pattern was evaluated with trauma series x-rays and a CT scan with 3D reconstruction.

Surgical Procedure: Internal fixation was performed with a volar locking plate. The plate was placed through a volar approach. Screws were placed in a different direction to buttress the distal radius.

Preoperative Planning: The choice of approach depended on the fracture pattern. A 2.7 mm locking compression plate was used. Kirschner wires were used for additional distal radioulnar joint stabilisation.

Patient Positioning: The patient was supine on a radiolucent table with the arm by the side. An image intensifier was positioned under the arm-board to visualise the distal radius, distal ulna, and the articular surface.

Surgical Technique: General or regional anaesthesia was used, and a volar approach was used to access the distal radius. Open reduction and internal fixation were performed using a locking compression plate and 2.7 mm screws. The ulnar styloid was fixed with Kirschner wires if it was fractured. The wrist was immobilised in an above-elbow cast for four weeks.

Postoperative Protocol: Antibiotics were given for three days, and the hand and forearm were elevated for 48-72 hours. Active range of motion exercises was started immediately. The cast was removed after four weeks, and patients were not allowed to lift heavy weights for 12-16 weeks.

Radiographic Evaluation: Posteroanterior and lateral radiographs were taken at follow-up. Lindstrom's criteria were used to assess the radiographic results.

Clinical Evaluation: Patients were evaluated for time to return to work, wrist pain, range of motion, grip strength, and Mayo Wrist Score.

RESULTS

In our study, males predominated with a ratio of 13:1, and the average age was 42.8 years. Seventeen

patients had a left-sided injury (60%), and 11 had a right side.

Table 1: Demographic data of the study

		Number of patients
Gender	Male	26
	Female	2
Age group	18-20	3
	21-30	6
	31-40	6
	41-50	4
	51-60	7
	61-70	2
Side	Right	11
	Left	17
Mode of injury	RTA	24
	Fall outstretched	2
	Fall from height	2
Fracture classification	B1	2
	B2	2
	B3	4
	C1	5
	C2	7
	C3	8

Table 2: Associated injuries in the study

Associated injuries	Number of patients
# Shaft of femur ipsilateral	2
# Shaft of femur contralateral	2
# Both bones Leg ipsilateral	2
# Tibial Plateau	2
# L1	2
# L3	1
C5C6 subluxation without Neurological deficit	1
# Pubic rami	2
# Olecranon ipsilateral	1
Crush injury contralateral arm	1
Crush injury leg contralateral	1
# Calcaneum	2
Compartment syndrome	1
# Proximal Humerus contralateral	1
# scaphoid	2

Table 3: Mayo Wrist Score

Results	Number of patients
Excellent	17 (65%)
Good	5 (19%)
Satisfactory	2 (8%)
Poor	2 (8%)

Table 4: Coexistence of Ulnar Styloid Fracture with DRUJ Instability & its Outcome

Studies	No of patients	# of US	Nonunion in %	DRUJ instability	Mayo, Good to Excellent
Phadins et al. ^[4]	183	45%	32%	1%	74%
Louis Catalano et al. ^[16]	21	48%	50%	21%	47%
Sammer DM et al. ^[18]	144	61%	41%	1%	52%
Kazemian GH et al. ^[19]	112	23%	11%	9%	45%
Buijze et al. ^[20]	36	100%	64%	Nil	64%
Our study	28	32%	10%	22%	55%

Table 5: Radiological evaluation after fracture union

Studies	RUI	RL in mm	RI in degrees	VA in degrees
Jupiter et al. ^[12]	65%	10	21	7
Anakwe R et al. ^[13]	67%	11	20	10
Fitoussi F. ^[14]	43%	9	20	3
Orbay J et al. ^[15]	99%	10	21	13
Our study	89%	10	19	13

Table 6: Objective functional outcome

Studies	PF in degrees	DF in degrees	Pr in degrees	Sup in degrees	RD in degrees	UD in degrees	GS in degrees
Jupiter et al. ^[12]	66	58	72	78	22	42	71%

Anakwe R et al. ^[13]	64	62	62	78	20	34	80%
Fitoussi F. ^[14]	52	52	68	88	14	26	76%
Orbay J et al. ^[15]	47	44	77	76	22	32	65%
Our study	58	56	64	72	24	30	72%

Table 7: MAYO Wrist Score

	Excellent	Good	Fair	Poor
Jupiter et al. ^[12]	63	20	17	-
Anakwe R et al. ^[13]	24	60	16	-
Dennison et al. ^[22]	80	20	-	-
Our study	52	24	16	8

RTA was the predominant mode of injury, and the ulnar styloid process was fractured in 9 patients, of which four belong to ulnar tip fracture and the remaining five involve the basi styloid fracture.

Muller's type C fractures predominated in 71% of patients, of which C3 account for 40%. Six of the 28 patients presented with significant co-morbid illness in the form of diabetes mellitus or systemic hypertension, which were adequately controlled before surgery.

All patients belonged to lower socioeconomic strata of the society with moderate building and nourishment.

All the patients belong to the closed injury category, and most patients (90%) operated within three days from the time of injury. Twenty of our patients are polytrauma and associated with other long bone fractures. Appropriate Internal/External fixation methods stabilise these patients.

Of the 23 patients, 2 had head injuries and required neurosurgical intervention. Neurovascular status was intact in all patients. Surgery was delayed an average of 4.4 days (range 12-18). Tourniquet was used in 2 patients, and hemostasis was achieved with diathermy in all patients. 19 patients were approached via the standard volar Henry approach and nine via the extended volar carpal approach.

The fractured ulnar styloid fragment was not fixed in 9 patients. 2 patients had DRUJ transfixation with K wires, and 2 had a radial styloid fixation with a 3.5mm cortical lag screw. 2 patients had previously undergone external fixation elsewhere for a C3 type fracture. They were subsequently treated with ORIF and volar LCP after removing ligamentotaxis.

was 100ml (range 50-250ml). Bone grafting was not required in any cases due to using a volar plate. The distal radius and articular congruity reduction were confirmed with an image intensifier, and the drain was used in all patients.

Mobilisation of the wrist and hand was initiated from the 2nd post-operative day as tolerated by the patient. Patients with severe bone loss or gross intra-articular comminution were immobilised in a below-elbow cast for four weeks.

Of the 28 patients, 26 had regular follow-ups. Two patients were lost to follow-up. The mean follow-up was six months (range 3-18 months).

Union: Good bony union was achieved in all patients. The mean time to union was 12 weeks (range 10-18 weeks). 84% of patients healed by 12 weeks, and the remaining 16% took longer to recover, with one case of delayed union. Longer duration to union was noted in patients with comminution and bone loss severity.

Malunion: There were three cases of malunion due to loss of reduction with fracture collapse. This resulted in an intra-articular violation of screws in two cases.

Nonunion: Nine cases of the basi styloid ulnar fracture group nonunion. The ulnar styloid component was not addressed in this study.

84% of patients had excellent radiological outcomes, 11% had a good result, and < 5% had fair or poor results scores based on Sarmiento's modification of Lindstrom's criteria.

The mean range of motion was: Palmar flexion: 75 degrees (55-90°), **Dorsi flexion:** 60 degrees (55-85°), **Supination:** 70 degrees (55-80°), **Pronation:** 65 degrees (45-75°), **Ulnar deviation:** 20 degrees (20-35°), **Radial deviation:** 15 degrees (7-23°), **Grip strength** was, on average, 80% of the opposite normal side (range 50-100%). Rotational movements were lower in three patients with malunion. Grip strength and range of motion were lower in older patients who were less cooperative with physiotherapy and in patients with severe comminution and bone loss who were immobilised in a cast for longer.

Complications: Two patients had screws that trespassed the articular surface into the wrist joint, resulting in erosion of the distal fragment, and these screws were removed after four weeks. Three patients who were delayed in presenting to the hospital had stiffness in the wrist and hand. This was overcome with aggressive physiotherapy. One

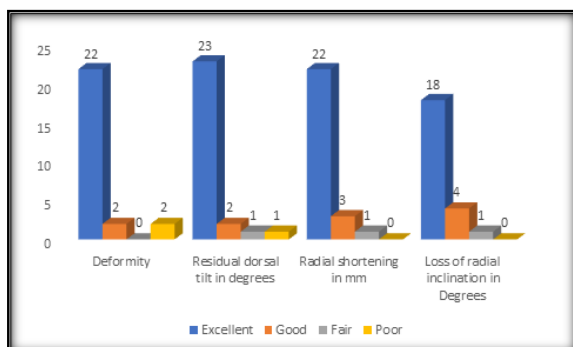


Figure 1: Sarmiento's modification of Lindstrom's criteria

The average surgery time was 1 hour and 20 minutes (40-200 minutes). The average blood loss

patient had a deep infection, treated with wound debridement and antibiotics. The condition resolved, but the comminuted fragments were resorbed, resulting in malunion. Three wrists showed Grade I osteoarthritis on plain radiographs. There were no cases of iatrogenic neurovascular injury, implant breakage, or tendon rupture.

DISCUSSION

Intra-articular distal radius fractures and their complex nature are increasing due to rising road traffic accidents. In our study, around 90% of patients are due to RTA and present with polytrauma. The exact incidence has not been reviewed in the literature.^[10,11] In our study, 22 of 28 cases (80%) are type C distal radius fractures, which explains the more and more complex presentation of these fracture patterns. Our study's average age of 45 is comparable to Jupiter DL et al. and Anakwe R et al., which had an average age of 43 & 48, respectively.^[12,13]

Our study had a male preponderance, with 26 cases out of 28 comparable to Fitoussi F & Chow SP et al. and Orbay J et al, which were 92%, 90% and 89%, respectively.^[14,15] The higher incidence among males would be due to higher involvement in road traffic accidents. In our study left side (non-dominant) was involved in 56% of cases and is comparable to Arora R et al. and Louis Catalano et al.'s study as 52% and 61%, respectively.^[5,16] All in our study belong to either type B or type C of distal radius fractures and graded the severity accordingly. Type C fracture account for 81% of our study, comparable with Louis Catalano et al. reported 80%.^[16]

The new implant choice, the fixed angled 2.7 mm locking plates, was used in all our patients, with a maximum number of screws in the metaphyseal region in the desired direction of anchorage. Fixation of the ulnar column was stressed for better wrist function and to avoid late distal radio ulnar instability stated by May Megan & Belloti et al.^[10,17] Then studies like Sammer DM et al. stated that stable DRUJ after fixation of the distal radius with angle stable volar locking plate needs no further surgical intervention for medial column fracture.^[18] But those with persistent DRUJ instability after distal radius fixation were stabilised by distal radioulnar transfixation K wire for four weeks. Vigorous wrist mobilisation protocol after transfixation wire removal resulted in good functional outcomes even in these groups.

In our study, of nine patients with co-existent ulnar styloid fractures, 7 had stable DRUJ after radius fixation with volar LCP. The remaining 2 had unstable DRUJ, stabilised with K wires for four weeks. Removal of the K wires and vigorous wrist mobilisation resulted in good functional outcomes. The MAYO score in these groups presented 55% good to excellent functional outcomes [Table 4].

The base of the ulnar styloid fracture will be aligned when the radial and intermediate columns are fixed. If necessary, the DRUJ can be stabilised with a transfixation wire. The clinical assessment of the DRUJ is difficult in the emergency room, but it can be assessed under anaesthesia after rigid fixation of the distal radius. Improved biomechanical understanding of the ligaments of the wrist led to the development of the reefing technique and the placement of the plate more distally in the volar aspect. This allows screws in the distal metaphyseal fragment to buttress the fragments and prevent a collapse of the articular comminution.^[21]

Various studies of fixation for distal radius are coming forth. The newer one introduces variable angle locking screws, which ply 15*-20* in all directions and lock with the plate. The average range of radiological evaluation of various studies was comparable with our study [Table 5].

The average range of functional outcomes of various studies was comparable with our study [Table 6].

Good functional results have been reported with any treatment modality in low-energy fractures in older people. However, the ideal treatment for high-energy injuries with associated distal ulna fractures is still being debated. The goals of the treatment are anatomical reduction of the distal radius articular surface and achieving distal radio ulnar congruity and early mobilisation. Our study had 52% excellent results based on the Mayo Wrist score and is comparable to other studies [Table 7].

The complications were minimal and comparable to other studies. There were four patients with prominent wires, one case of superficial infection, and four patients with wrist and hand stiffness. In our study, two distal radio ulnar instability was identified after stable fixation of the distal radius, necessitating additional K wire fixation and immobilisation in the above elbow slab for four weeks. Later it was removed, and vigorous wrist mobilisation started. The results of these subgroup patients were comparable to studies like Dennison et al.^[22]

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

CONCLUSION

The study concludes that early primary fixation of the distal radius fractures was essential for good functional outcomes and to avoid complications of prolonged immobilisation, which facilitates early return to regular activities. Patients with unstable, either volar or dorsally displaced fractures of distal radius had excellent or good functional outcomes when treated with fixed angle volar locking plate. A stable DRUJ after fixation of distal radius fractures using an angle stable volar locking plate maintained

DRUJ stability. The coexistence of ulnar styloid fracture in these patients did not affect functional outcomes. Patients with persistent DRUJ insatiability were stabilised with radioulnar transfixation wire for four weeks. Then it was removed, and vigorous wrist mobilisation resulted in a good functional outcome. However, long-term follow-up is needed to validate these findings further.

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