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Original Article

Augmentation of Volar Locking Plate with Percutaneous Kirschner Wires in Management of Unstable Distal Radius Fractures

Neetin Mahajan[1], Jayesh Anant Mhatre[2], Pritam Talukder[2]

[1]Professor and Unit Head, Department of Orthopaedics, Grant Government Medical College, Mumbai, Maharashtra, India, [2]Junior Resident, Department of Orthopaedics, Grant Government Medical College, Mumbai, Maharashtra, India

Abstract

Background: Distal radius fractures are common and are increasing in incidence, especially in older age group and younger population. There is spectrum of methods of treatment available ranging from closed reduction to various surgical procedures, with each one has its own benefits and complications. Our technique involves open reduction and internal fixation with locking plate (LCP) and augmentation of the fracture with percutaneous Kirschner wire (K-wire), and POP immobilization of the unstable distal radius fracture for 4–6 weeks. This study examines the functional outcome of volar plating with K-wire augmentation in unstable distal radius fractures.

Material and Methods: This is a prospective study conducted in a tertiary care hospital of 48 patients aged between 21 years and 71 years, with unstable distal radius fracture. Patients were treated by open reduction and internal fixation with LCP and percutaneous pinning using two to three K-wires to maintain radial inclination and stability of radial styloid fracture fragment. The wires are cut and bent to the outside. A dorsal below elbow POP slab was applied for 4–6 weeks. K-wires were removed at interval of 6–8 weeks. All the patients were followed up at regular intervals of 3 weeks, 6 weeks, 12 weeks, and 24 weeks. The functional evaluation was done at 24 weeks follow-up. We applied Sarmiento's modification of Lindstrom criteria and Gartland and Warley criteria for the evaluation of results.

Results: Excellent to good results were seen in 83.33% of cases, fair results in 15.73%.

Conclusion: Augmentation with percutaneous pinning of LCP is a simple, functionally effective, safe method to maintain the fracture reduction of the principle columns of distal radius, it is easily reproducible and has less interference of the soft tissue, compared to the standard dual plating method which is used routinely.

Key words: Distal radius fractures, K-wire augmentation, Locking plate

INTRODUCTION

Fracture of the distal radius and ulna is the most common fracture encountered by orthopedic trauma surgeons around the world. The history of fractures of the distal radius reflects the evolution of the understanding of many conditions in orthopedic trauma. Fractures of the distal radius were brought to the attention of the English speaking literature in 1814 when Abraham Colles published his views "On the fracture of the carpal extremity of the radius" in 1814.[1]

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At present, for the management of distal radius fracture, a spectrum of modalities is available ranging from closed reduction and immobilization to open reduction and internal fixation, as present knowledge stands, we cannot predict the outcome of a distal radius fracture with any degree of confidence but we can only recommend levels of displacement which can be accepted in the fit, active, and fully functioning patient. Selection of patient for a particular treatment is very important and should be given meticulous care, broadly, the patient selection should depend on metaphyseal stability, articular involvement, and displacement of the fracture at the time of presentation.[2,3]

According to the "three-column theory" of distal radius fractures proposed by Rikli and Regazzoni. Distal radius and ulna fractures are classified under the columnar classification system it further divides the distal radius and

Corresponding Author: Dr. Jayesh Anant Mhatre, Department of Orthopaedics, Grant Government Medical College, Mumbai, Maharashtra, India.

ulna into three columns: (1) Lateral distal radius (radial styloid and scaphoid facet), (2) medial distal radius (lunate facet), and (3) the ulnar column (TFCC and ulnar styloid).[1-3]

In this study, we aim to analyze radiological and clinical outcome in unstable distal end radius fracture managed with volar plating and Kirschner wire (K-wire) augmentation; what constitutes distal radius "unstable" fracture, there is no firm description of unstable radius fracture, however, we can say that instability, or the inability of a fracture to resist displacement after closed reduction, is often defined according to criteria regarding initial displacement, such as dorsal angulation, shortening, and the presence of dorsal comminution.[4] The definition is in fact an assessment of the probability that a fracture will redisplace. Maintaining reduction with acceptable radiological parameters is of essence in treatment of such injuries, we, in our study, have attempted to achieve optimal results with open reduction with volar plating and augmenting with 2–3 K-wires, which were used to maintain alignment and rotation of lateral distal radial and medial radius column. At present, for the management of unstable distal radial fractures, dual plating (volar and styloid plate) or external fixation with K-wire augmentation is used,[5] our method aims to provide less invasive and easily reproducible alternative to dual plating and early mobilization with prevention of complications of stiffness compared to external fixation.

MARERIALS AND METHODS

Forty-eight patients with unstable distal radius fracture were prospectively selected for the study between 2019 and 2021 in tertiary care hospital orthopedic department. Male cases were 27 and 21 cases are female. The mean age of the patients was 51 years. In 36 patients', dominant hand was fractured. All the fractures were unstable comminuted and intra-articular, presenting within 1–3 days of injury. All 48 patients were under regular fallow-up. The common cause of injury was fall on outstretched hand in 36 patients, and 10 cases were due to road traffic accident and remaining two cases the fracture were sustained due to sports-related injury. All are closed fracture and classified according to AO/OTA [Figure 1] using anteroposterior (AP) and lateral view X-rays [Figure 1]. Twenty-two cases were B3, and 18 cases were C1, and eight cases are C2. In addition, radial length, palmer tilt, and radial angulations were measured.

Selection Criteria

Inclusion criteria

- Clinical signs and symptoms
- Radiological findings conforming intra-articular fracture of distal end radius
- Patients who are medically fit and willing for surgery
- Patients between the age groups of 18 and 75 years of both sexes.

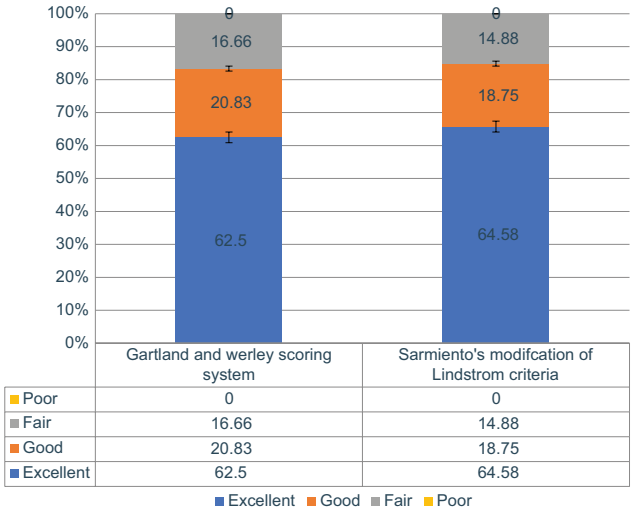
Exclusion criteria

- Patients below 18 years and above 75 years
- Distal end radius fracture associated with other injuries around the wrist joint of same limb
- Pathological fractures
- Distal end radius fracture associated with neurovascular deficit
- There is evidence that the patients will be unable to adhere to trial procedures or complete questionnaires
- Patients with any open wound on same limb.

Patient demographics	
Range of age at time of presentation	21–71 years
Mean age at the presentation	39.15±30.12
Male patients	27
Female patients	21
Fracture subtype B3	22
Fracture subtype C1	18
Fracture subtype C2	8
Right hand dominance	27
Left hand dominance	21
Total number of patients	48

Parameters	Postoperatively at 6 weeks	At 1-year follow-up
Radial inclination	21.06±3.25 degrees	20.96±4.40 degrees
Radial height	10.12±1.48 mm	10.06±1.18 mm
Palmar tilt	9.64±5.84 degree	9.55±5.18 mm
Ulnar variance	−0.28±0.68 mm	−0.12±1.10 mm

Parameters	Postoperatively at 6 weeks	At 1-year follow-up
	In degrees	In degrees
Flexion	40.12±14.15	61.13±12.45
Extension	29.15±7.40	50.65±18.42
Supination	55.10±9.10	77.42±11.38
Pronation	74.10±8.10	84.32±5.30
Grip strength (compared to the opposite side)	56.45±20.45	89.50±4.25



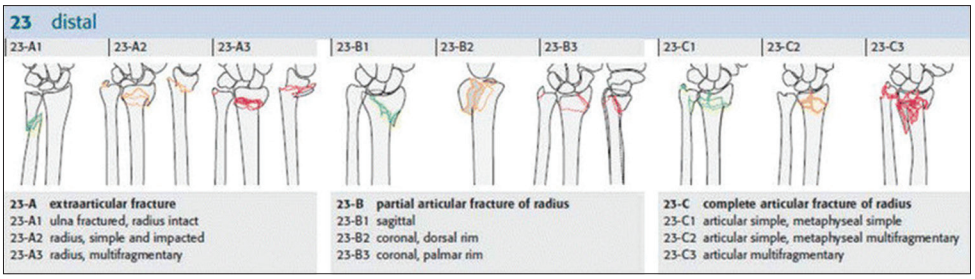


Figure 1: Classification of distal radius fractures

Surgical Approach for Volar Plate Fixation

All surgeries were performed under regional or general anesthesia under fluoroscopic guidance. With the patient positioned on the operating table, the skin incision was made after palpating the flexor carpi radialis tendon (FCR). The sheath of FCR was split and the FCR was retracted ulnar ward. The interval was developed between the FCR tendon and the radial artery. The pronator quadratus (PQ) was exposed, and incision was made over the radial border of the PQ. The fracture site was exposed, and the periosteum was elevated using a periosteal elevator. The fracture was the reduced using a volar and ulnar directed force with traction being applied to maintain reduction, a K-wire was inserted through the fracture site from the radial styloid to stabilize the styloid fragment of fracture and another K-wire from listers tubercle to maintain apposition of the dorsal fracture fragments. An appropriately sized distal radius LCP was selected depending on the fracture pattern. The plate was fixed under the guidance of the image intensifier and the articular reduction was maintained with subchondral screws. At the end of the procedure, the detached end of the PQ was reattached to the edge of brachioradialis to provide coverage for the distal plate. Carpal tunnel was not decompressed in any of our cases. Distal radioulnar joint (DRUJ) instability was assessed in all cases intraoperatively after the fixation of the distal radius by ballottement test, with the forearm in a neutral position. DRUJ instability was suspected if there was a soft endpoint with an increase in the AP translation of 5–10 mm as compared to the uninjured wrist. In such cases, DRUJ was temporarily transfixed with radioulnar K-wire for a period of 4 weeks and the wire was removed in the outpatient department. All the patients were operated through the same approach.

The skin was closed in layers after a thorough wash. A bivalve slab was applied in all cases and was maintained for a period of 3 weeks post-operative. Post-operative radiographs were taken. The patients were then reviewed at post-operative weeks 3, 6, 12, and 24. AP and lateral radiographs were taken during all the reviews, the slab and K-wires were removed at 6 weeks and wrist mobilization in terms of range of motion exercises and soft ball exercises to improve grip strength were started at week 3. During the final review at post-operative week 24, the final scoring of wrist function was done using the Gartland and Warley functional scoring and Sarmiento radiological score. The results were tabulated and analyzed.

Post-operative Management

Postoperatively, the limbs were placed into a bulky dressing, post-surgery active finger movements were encouraged. Suture removal was done on the 12th day. Ulnar deviation, palmer deviation, and active rotational exercise were started 6 weeks postoperatively.

Follow-Up Period

Patients were followed up post-operative visits at 2 and 6 weeks and 3, 6, and 12 months post-surgery. All relevant findings recorded in every visit, functional assessment system and radiological assessment of the fractures progression were done.

	Residual deformity	Loss of radial tilt (°)	Radial shortening (ml)	Loss of radial deviation (°)
Excellent	No deformity/ insignificant	0	<3	5
Good	Slight	1-10	3-6	5-9
Fair	Moderate	11-14	7-11	10-14
Poor	Severe	At least 15	≥12	>14

Sarmiento's modification of Lindstrom criteria.

RESULTS

Forty-eight patients between the age of 21 years and 71 underwent surgery for distal radius fracture. Mean age in patient was 39.15 years. All patients were active and independent. Table 1 shows patient demographics. About 66% of fractures were as a result of a simple fall; 17% in falls from bicycles, 15% in motorbike accidents, and 2 in blunt trauma. All fractures were unstable. Mean operating time was 85 min (51–118 min range). Mean time to surgery was 4.7 days (range 2–14 days). All fractures united between 9 and 17 weeks of surgery (mean 11 weeks). Table 2 shows range of the wrist movements. Mean VAS was 1.6 (range 0–7), mean grip strength was 84.5 (range 55–98). The complication rate was 17.1% [Figures 2-7].

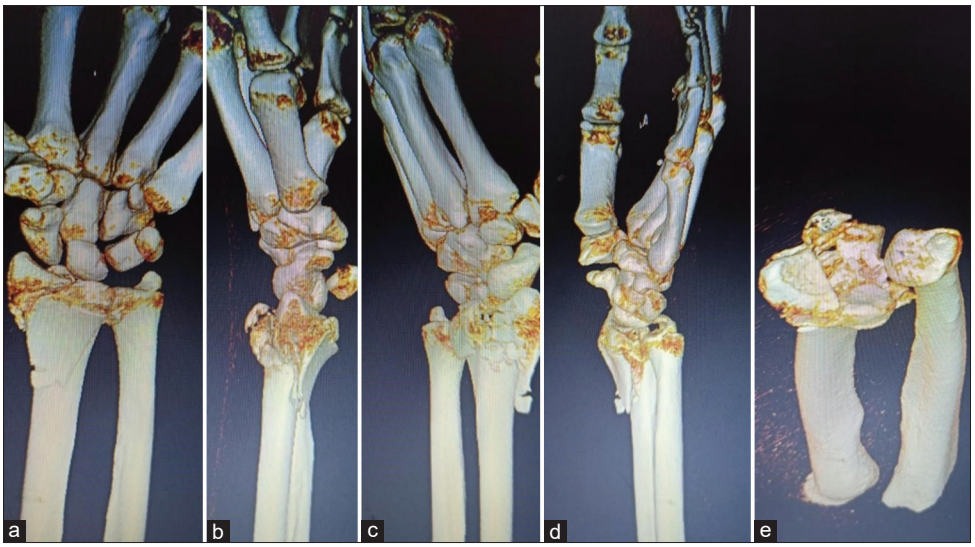


Figure 2: (a-e) Computed tomography showing fracture pattern

Figure 3: (a-e) Surgical approach and intraoperative images

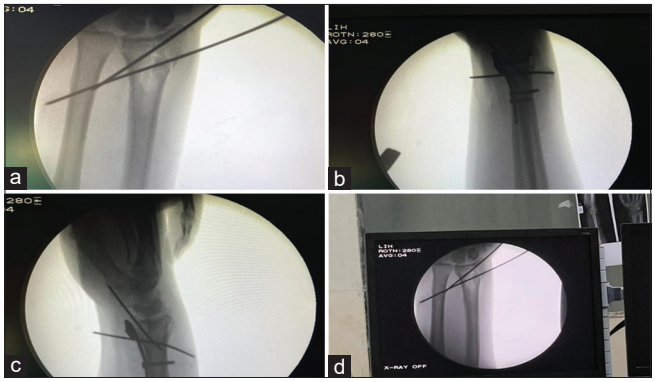


Figure 4: (a-d) C-arm images showing use of K-wire for achieving initial reduction

DISCUSSION

Fracture of the distal radius remains the most common fracture treated by orthopedic trauma surgeons, but despite this, there is no consensus about the treatment of more complex cases with metaphyseal instability or intra-articular displacement.[6] Surgical treatment must address both the intra-articular displacement and any accompanying metaphyseal displacement and instability, so a combination of techniques may be required. Each fracture must be assessed to ascertain the fracture pattern and displacement of the fragments and a treatment strategy defined on this basis.[7] A knowledge of the typical fracture patterns as described by Melone is useful. He described four parts – radial styloid, dorsal, and ulnar volar fragments, and the radial shaft. As the lunate impacts on to the articular surface, the lunate facet may be depressed as one or split into a volar and dorsal component with added central impaction.[8] The impact of the scaphoid on the radial styloid typically causes a shearing fracture. An understanding of this mechanism is helpful to the surgeon in planning procedures.

Figure 5: (a-d) Radiographic images showing union at fracture site, removal of K-wires was done when union was visible

Figure 6: (a-d) Clinical outcome at 6 months

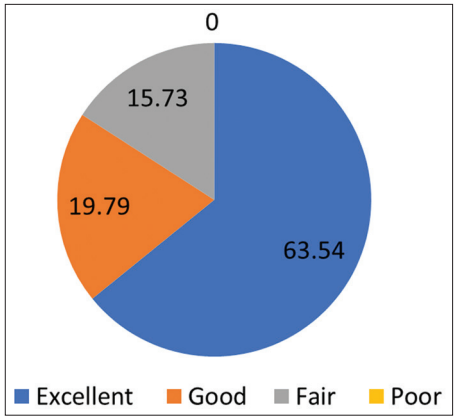


Figure 7: Clinico-radiological outcome

Previous biomechanical studies have suggested that the middle column of the distal radius is primary load-bearing surface, which transmits an axial load to the wrist and has a major role in mechanical conduction.[9] The fracture line of middle column of the distal radius is mostly vertical. The radial column of the distal radius mainly stabilizes the wrist and controls rotation and its fracture line is usually horizontal,[10] so the styloid fracture fragment is prone to rotation, even though a screws from locking plate (LCP) hold and compress the displacement but there is a need for additional support to maintain radial inclination and height, for this conventionally radial styloid plating with volar plating was done, we in our study have used K-wire augmentation to achieve stability.

The goal of treatment is to achieve a painless wrist with a good function. Malunion can result in persistent pain, reduced range of motion, decreased grip power, limitation in day-to-day activities, which can be disabling.[11,12] Various surgical treatment options are available for the treatment of distal radius fractures. Each technique has advantages and disadvantages. Intramedullary nailing for distal radius fractures is not used too often due to a higher complication rate.[13] Closed reduction and K-wiring are less costly but drawbacks are prolonged immobilization, pin-tract infection, stiffness, and complex regional pain syndrome, may not be sufficient in comminuted fractures, and loss of reduction after removal of K-wires. Grip strength and supination is better in patients with unstable distal radius fractures treated with a volar locking than those treated with closed reduction and percutaneous K-wiring only.[14] External fixation once popular is not used widely now due to a variety of reasons that include post-operative stiffness, patient inconvenience, pin-tract infection, pin loosening, loss of reduction following removal, median, and superficial nerve neuropathies.[15,16] External fixation when compared with plating for unstable distal radius fractures has higher complications including infection and malunion. The clinical and radiological results of a volar LCP are superior to a non-bridging and bridging external fixator in treatment of intra-articular comminuted distal radius fractures. Dorsal plating was once popular but not used widely due to late complications and volar collapse when compared with volar LCP and no difference in outcomes. The use of a volar LCP with K-wire augmentation proves beneficial in restoration of the anatomy, stability,

shorter duration of immobilization, early range of motion exercises, and early return to function.

In our method, we used volar plating it allowed direct visualization of fracture fragments, which were reduced and maintained with two or three K-wires, one from radial styloid to hinder its rotation and one or two K-wires from dorsal aspect for maintaining anatomical volar tilt, it aided in restoration of the anatomy, decreased morbidity by allowing early mobilization, and early return of wrist function. LCP s address intra-articular and metaphyseal comminution and are mostly helpful in osteoporotic fractures preventing late collapse of fracture fragments.[17] Biomechanical studies comparing volar fixed angle LCP s with that of conventional dorsal plates report volar fixed-angle plates to be superior in terms of their strength.[18] Dorsal plating of distal radius has lost popularity due the fact that, in spite of dorsal plating, the volar collapse of fracture occurred which resulted in malunion and a second surgery in later period.[19] Complications associated with plating include risk of infection as compared to closed procedures, tendon irritation, or rupture. These may warrant implant removal in some cases.[20,21]

In our study, the dominant side which was injured recovered early, with grip strength 96% of the contralateral side at 6 months follow-up and remained the same at 1 year of follow-up. Grip strength of the non-dominant injured side reached about 84% of the normal side even at 1 year of follow-up. Pronation improved more rapidly than supination at 6 weeks of follow-up but both returned to

Results	Points
Residual deformity	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	2-3
Point range	0-3
Subjective evaluation	
Excellent. No pain, disability, or limitation of motion	0
Good. Occasional pain, slight limitation of motion, no disability	2
Fair. Occasional pain, some limitation of motion, feeling of weakness in wrist, no particular disability if careful, activities slightly restricted	4
Poor. Pain, limitation of motion, disability, activities more or less markedly restricted	6
Point range	0-6
Objective evaluation	
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
Point range	0-5
Complications	
Arthritic change	
Minimal	1
Minimal with pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complications (median)	1-3
Poor finger function due to cast	1-2
Point range	0-5
End-result point ranges	
Excellent	0-2
Good	3-8
Fair	9-20
Poor	21 and above

Gartland and Warley demerit scoring system

near normal at the 1 year of assessment. At the end of 1 year follow-up, 63.54% of patients had excellent and 19.79% had good results, 15.73% of patients had fair results, and no one had poor outcome.

CONCLUSION

We conclude that fixation of distal radius fracture with LCP and stabilization of the styloid fracture fragment with K-wire augmentation had a favorable impact on the outcome of the study. For unstable fractures of the distal end of radius, volar LCP osteosynthesis with K-wire augmentation is a valid and effective treatment option ensuring a successful functional and radiological outcome.

CONSENT

Written informed consent was obtained from all the patients for publication of this report and accompanying images.

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