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Volar locking plate fixation for unstable distal radius fractures- A prospective study of functional and anatomical outcome

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Introduction

Distal end radius fractures represent approximately one-sixth of all fractures treated in the emergency department.[1,2]

Fractures of the distal radius continue to pose a therapeutic challenge. Some of these fractures are caused by severe high energy trauma, resulting in intra-articular involvement and comminution, while some result from trivial trauma especially in the elderly. These fractures often are unstable, are difficult to reduce anatomically, and are associated with a high prevalence of complications like distal radio ulnar joint [DRUJ] instability, malunions, delayed fracture collapse, post-traumatic osteoarthritis. It is also known that extra-articular malalignment can lead to decreased grip strength and endurance as well as limited motion and carpal instability.[3,4]

Plaster application was the choice of treatment in the past which was fraught with compromising results. Pins were added to plaster to give more stability which resulted in improved outcomes, however, unstable fractures and osteoporotic fractures continued to fare worse.

External fixator was based on ligamentotaxis, in which the fracture fragments were moulded by traction forces across the ligaments. There was a risk of over distraction of the joint and development of finger stiffness with the bridging fixators. The frequency of pin tract infections was also a concern. There was a higher incidence of loss of range of motion.[5] The problems with external fixation have prompted a search for a better treatment option and now internal fixation has become the preferred treatment modality.[6]

Locking compression plate (LCP) is a screw-plate system developed by combining the traditional plating techniques with the principles of AO internal fixator. These plates provide stable fixation, thereby maintain the reduction, reconstruction of articular congruity and reduce the incidence of post-traumatic osteoarthritis.[7] The use of pre contoured angular stable plate fixation is characterized by higher stability by improved pullout strength even in osteoporotic bone.[8] These implants afford osseous fixation that allows early motion and rehabilitation.[9]

Over the past decade, there has been an increasing interest in plate fixation, especially volar locking compression plate fixation of distal radius fractures. The purpose of this study is to evaluate the functional and anatomical outcome of unstable distal radius fractures treated by volar locking compression plate.

Materials and Method

This prospective study was carried out at BIRRD[T] Hospital during 2011 to 2014. Forty eight patients with unstable fractures of the distal radius treated with open reduction and internal fixation with volar LCP were included in the study. Lafontaine 's criteria for instability were used to assess the fracture stability. A fracture is deemed unstable if it fulfills three or more of the five criteria - dorsal tilt more than 20°, dorsal comminution, intra articular fracture, associated ulna fracture, age more than 60 years.[11] All unstable fractures were included. The exclusion criteria were pathological fractures, open fractures, fractures with neurovascular injuries. AO/OTA classification was used to classify the fractures.

All the patients were initially managed as per ATLS protocol. After stabilising the patient, the plan for surgical intervention was explained and informed consent was taken.

All the patients were operated under brachial plexus block and under tourniquet control. Volar Henry approach was employed in all patients. An incision was made between the flexor carpi radialis (FCR) tendon and the radial artery. This interval was 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 was carefully retracted radially, while the tendons of the FCR and FPL were retracted ulnarly. The pronator quadratus was divided at its most radial aspect, elevated medially, leaving a small cuff of muscle for later reattachment. The fracture site was visualized, reduction was achieved by manual traction, reduction clamps, provisional K wire fixation as deemed necessary. By using the image intensifier, the parameters of radial height, radial inclination, palmar tilt, ulnar variance were checked for appropriate reduction. Appropriate plate was chosen to complete the definitive fixation. Supplementary K wires were added when necessary. Distal radioulnar joint stability was assessed after plating and was fixed with a K wire in reduced position if found unstable, to be removed after 4 weeks. Wound was closed in layers. Below

elbow plaster slab with the wrist in neutral position was applied till suture removal.

Immediate post-operative check radiographs were taken in both anteroposterior and lateral views. Active exercises of all the fingers, elbow and shoulder were carried out. After suture removal, volar slab was removed and wrist mobilization exercises were taught. The patients were followed up at

6 weeks, 3months, 6 months, 1 year and every 6 months later on as necessary. The assessment of functional results were made using the demerit system of Gartland &Werly [Table 2] based on residual deformity, subjective evaluation, objective evaluation & complications. Sarmiento's modification of Lidstrom's criteria was used for assessing anatomical outcome. [Table 3]

Results

Table 1: Age Incidence

Age in Years	No. of Cases	Percentage %
21-30	10	20.83%
31-40	14	29.16%
41-50	8	16.66%
51-60	9	18.75%
61-70	7	14.58%

In this series 10(20.83%) patients were between21-30years, 14(29.16%) between 31-40years, 8(16.66%) between 41-50years, 9(18.75%) between 51-60years, 7 (14.58%) between 61 -70 years. The age of the patients ranged from 22-66years.

Out of 48 patients, 34(70.83%) were males and 14(29.16%) females.

Right side was involved in 28 (58.33%) patients and the left side was involved in 20 (41.66%) patients. Dominant side was involved in 34 (70.83%) patients.

In our study, there were 26(54.16%) patients who met with road traffic accidents and 22 (45.84%) patients have fallen on their outstretched hand.

According to AO/OTA classification, of the 48 fractures, 5 (10.41%) were of A3, 3(6.25%) were of B1, 13(27.08%) of B3, 16 (33.33%) were of C1, 4(8.33%) of C2, and 7 (14.58 %) of type C3.

Ulnar styloid process was fractured in 24 patients. No fixation was done in them. DRUJ instability was assessed after fixation of the distal radius and was present in 6 patients who had a transfixing K wire across the DRUJ after reduction. This K wire was retained for 4 weeks.

In the present study, 40 (83.33%) had union within 2-3 months and 8(16.66%) had union in 3-4 months. Bone grafting was not necessary in any of the patients.

At 12 month follow up, the average dorsiflexion was 48.37 ± 16.88 degrees, palmar flexion 63.35±10.43 degrees, pronation 82.37 ± 4.75 degrees, supination 75.85±12.62 degrees. All patients had ulnar deviation (minimum l5°) within the normal functional range. 36 patients (75%) had radial deviation within the normal functional range (minimum 15°). None of the patients (0%) had significant loss of grip strength (<60% compared to the opposite side). 4 (8.33%) patients had pain in the distal radioulnar joint.

Table 2: Functional outcome - Gartland & Werley Demerit system

Residual deformity	Prominent ulnar styloid	1
	Residual dorsal tilt	2
	Radial deviation of hand	2 or 3
Subjective evaluation	(Range 0 to 6 points)	
	Excellent: No pain, disability, or limitation of motion	0
	Good: Occasional pain, slight limitation of motion and no disability	2
	Fair: Occasional pain, some limitation of motion, feeling of weakness in wrist, no particular disability if careful, and activities slightly restricted	4
	Poor: Pain, limitation of motion, disability, activities more or less markedly restricted	6
Objective evaluation[l] (range 0 to 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 Opposite side	1
	Loss of pronation	2

Complications (range 0 to 5 s)	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	1-3
Result	Excellent	0-2
	Good	3-8
	Fair	9-20
	Poor	>20
[1] The objective evaluation is based upon the following ranges of motion as being the minimum for normal function: dorsiflexion 45°; palmar flexion 30°; radial deviation l5°; ulnar deviation l5°; pronation 50°; supination 50°		

Table 3: Anatomical Outcome - Sarmiento's Modification of Lidstrom's Criteria

Excellent	No or insignificant deformity. Dorsal angulation ≤ 0 ° Radial shortening<3 mm Loss of radial deviation <4°
Good	Slight deformity. Dorsal angulation l to 10 ° Radial shortening 3 to 6 mm. Loss of radial deviation 5-9°
Fair	Moderate deformity. Dorsal angulation 11 to 14 ° Radial shortening 7 to 11mm. Loss of radial deviation 10-14°
Poor	Severe deformity. Dorsal angulation > 15 ° Radial shortening > 12mm Loss of radial deviation >15°

The assessment of functional results were made using Gartland & Werley demerit system based on residual deformity, subjective evaluation, objective evaluation & complications. We had 22(45.83%) cases with excellent results and 22 (45.83%) cases with good results and 4 (8.33%) cases with fair results[Table 5] at the end of 12 months.

The radiological parameters analysed were radial length, radial inclination, palmar tilt and ulnar variance. These values at 12 month followup revealed that these were 10.47 ± 1.45 mm, 22.63 ± 3.78 degrees, 9.36 ± 4.84 degrees, -0.23±1.87mm respectively. As per Sarmiento's modification of Lidstrom's criteria used to assess anatomical outcome, 30 patients had excellent and 18 patients had good results.[Table 5]

2 patients had superficial wound infections.1 patient had flexor pollicis longus tendon irritation because of long volar plate in contact with tendon.2 patients had pain and l patient had discomfort due to plate. l patient had persistently painful and unstable DRUJ with a prominent distal ulna. None of the patients had median nerve complications.

Table 4: Results at 12 months follow up

Range of motion		**Radiographic criteria**	
Dorsiflexion	48.37 ± 16.88 °	Radial length	10.47 ± 1.45mm
Palmar flexion	63.35 ± 10.43 °	Radial inclination	22.63 ± 3.78°
Pronation	82.37 ± 4.75 °	Palmar tilt	9.36 ±4.84°
Supination	75.85 ± 12.62 °	Ulnar variance	-0.23 ± 1.87 mm
Grip strength [vs Contralateral]	87.45 ± 5.35%		

Table 5: Outcome scores at 12 month follow up

Functional outcome		**Anatomical Outcome**	
Gartland & Werley Score		**Sarmiento's modification of Lidstrom's score**	
Excellent [0-2]	22 [45.83%]	Excellent	30(62.5%)
Good [3-8]	22 [45.83%]	Good	18 (37.5%)
Fair [9-20]	04[8.33%]	Fair	00
Poor [≥21]	00	Poor	00

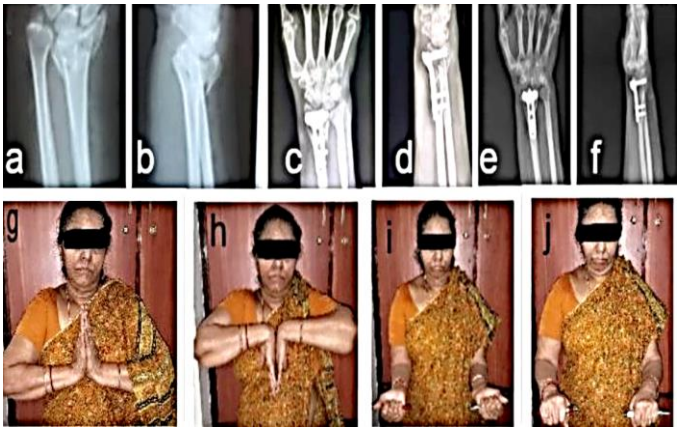

Fig. 1
a-b: Preoperative radiographs of a 58yr female, AO 23-C1 fracture
c-d: Immediate Postoperative Radiographs
e-f: Radiographs at 14 month
g-j: Functional outcome at 14 months

Fig. 2
a-b: Preoperative radiographs of a 52yr female, AO 23-C1 fracture
c-d: Immediate Postoperative Radiographs
e-f: Radiographs at 12 month (6 months after Darrach's resection)
g-j: Functional outcome at 12 months

Discussion

More than 190 years have passed since Colles described the fracture of the distal end of the radius. It is remarkable that this common fracture remains one of the most challenging of the fractures to treat. There is no consensus regarding the description of the condition and the appropriate outcome. There is still no unanimity regarding the best treatment option.[12]

Distal radius fractures are the most frequently seen upper extremity fractures. The main objective of its treatment is the re-establishment of anatomic integrity and functioning. In unstable intra-articular fractures, re-establishment of inter-articular integrity of the wrist and maintaining the radial length are often not possible with closed methods. In such cases, where an open reduction is required, various surgical methods and fixation materials can be used. A better understanding of wrist anatomy and functioning through the studies conducted in the recent years, as well as the increasing expectations of patients have expanded the borders of surgical treatment. Besides, improvements in fixation materials have provided new opportunities.

Due to their intra-articular and unstable nature, most of the fractures from Frykman type III to type VIII are treated surgically. Locking compression plates are being preferentially used over conventional plates. There is no consensus either about how to approach to distal radius or the positioning of the plate. Dorsal approach facilitates plating in buttress mode but implant prominence and proximity to extensor tendons causing tenosynovitis and rupture and risk of delayed collapse are major concerns. During the recent years, volar approach has become more popular. The present study was undertaken to assess the functional & anatomical outcome of operative management of unstable distal radial fractures using a volar LCP.

Volar approach allows reconstruction of the fractured fragments under vision, dealing with intra

articular comminution & displacement, restoration of the volar cortex which aids in the restoration of radial length. The Volar LCP gives stability to permit early wrist mobilization and thereby hasten the rehabilitation.[13,14] The plate is positioned under pronator quadratus keeping it away from flexor tendons avoiding irritation; scars on the volar aspect are better tolerated than those on the dorsal aspect.[15,16]

When compared to non-locking plates, Locking plates offer significant resistance to fracture gap motion.[17] Because of the angular stability offered by the locking screws, the possibility of the late collapse of these unstable fractures is minimized.

In the present study, 83.33% fractures united within 2 to 3 months and 16.66% united in 3-4 months. Bone grafting was not performed in any of the patients.

In our series, at the end of 12 months follow up, we had functionally 46% excellent, 46% good, 8% fair results and no poor result. Patients, who obtained excellent results had no residual deformity. Range of motion was within the normal functional range. They had no arthritic changes. Radial length, radial inclination, tilt, articular step-off were within acceptable limits. Patients with good results had minimal residual deformity and slight limitation of motion. Rest of their findings were within acceptable parameters. Patients with fair results, had pain in distal radioulnar joint along with residual deformity.

We did not encounter any significant loss of reduction which was evident in the radiological variables at the end of 12 month follow up.

The fractured ulnar styloid process was not fixed in any of the 24 patients and it did not have any significant effect on the outcome. This is in lieu with various studies which state that nonunion of ulnar styloid does not affect the outcome in adequately stabilized distal radius fractures.[18-21]

In 6 patients with demonstrable DRUJ instability as assessed intraoperatively after fixation of distal radius with LCP, we have used a transfixing K wire to stabilize DRUJ and retained for 4 weeks. All of these patients had restricted and painful pronation at 6 weeks but five patients went on to have full, painless rotations by 3 months. One patient continued to have persistently painful and unstable DRUJ with prominent distal ulna. We have done Darrach's excision at 6 months after which she was relieved of her symptoms.[Fig. 2] However, Lee SK et al[22] in their study found that the long term outcomes of DRUJ instability were similar in conservative as well as operative management. Liu J et al[23] suggest that fixation does not offer any advantage over non fixation.

We had a few complications in our study apart from the patient with DRUJ instability. 2 patients had superficial wound infection which was managed conservatively with IV antibiotics and dressings.1 patient had flexor pollicis longus tendon irritation because of its proximity to a long volar plate, 2 patients had pain and 1 patient had discomfort due to plate. Implant removal was done at 6 months after fracture union and the symptoms were alleviated in these patients.

Conclusion

Volar LCP is an effective treatment option in dealing with unstable distal radius fractures which facilitates and maintains anatomic realignment, prevents delayed collapse, allows early joint motion and results in successful functional and anatomical outcomes. The associated ulnar styloid fractures though not surgically managed do not affect the outcome. The complication rate with this surgical modality.

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