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ORIGINAL RESEARCH ARTICLE

FUNCTIONAL OUTCOME OF VOLAR LOCKING PLATE FOR UNSTABLE DISTAL RADIUS FRACTURES

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ABSTRACT

Introduction: Distal radius fractures are the most common fractures in elderly. Unstable fractures are best managed surgically and the results of volar locking plates have been promising. The purpose of this study is to determine the functional outcome of volar locking plates in the treatment of unstable distal radius fractures. **Methods**: Forty-five patients with 46 unstable distal radius fractures were enrolled for this study, conducted at Chitwan Medical College from September 2016 to April 2017. All patients were treated with a 3.5mm titanium volar locking plate and followed-up for a minimum of one year. The assessment was done using radiological evaluation and Cooney modification of the Green and O'Brien scoring system. **Results**: Twenty-three men and 22 women with age ranging from 15-75 years (mean 43.22 years) were followed-up for an average of 16.53 months. There were 17 type A fractures (5 A2, 12 A3), 11 type B fractures (3 B1, 1 B2, 7 B3), and 18 type C fractures (4 C1, 12 C2, 2 C3) (AO classification). The mean time for union was 7.96 weeks. Functional outcome using modified Green and O'Brien Score was 20 excellent, 15 good, 7 fair and 4 poor results (76.1% good to excellent results). The overall complication rate was 15.22%. **Conclusion**: Volar locking plates provide adequate fixation for unstable distal radius fractures with minimal loss of reduction and satisfactory functional outcome.

Key words: Complications, Distal radius fracture, Outcome, Volar locking plate.

INTRODUCTION

Distal radius fractures are the most common fractures occurring in the elderly individuals. The goal of surgical fixation in the unstable distal radius fracture is to restore intra-articular and extra-articular anatomic alignment.[1-3] This greatly reduces the incidence of post-traumatic arthritis and also the quality of reduction relates directly to the final outcome.[4] Various surgical treatment methods are available – pinning, external fixation and open reduction and internal fixation with volar or dorsal locking plates. Fractures treated with external fixation require prolonged immobilization at least for six weeks.[5-7] Volar locking plates have the advantage of stable subchondral fixation, early postsurgical active wrist motion, restoration of articular and extra-articular alignment, and fewer complications when compared with external fixation.[8,9] Dorsal plating has been established as a safe and effective method for treatment of dorsally displaced fracture[10-13], but is associated with complications of tendon rupture, tenosynovitis, reoperation, fracture collapse while the complication of volar plating is relatively low.[14] Studies have shown that volar locking plates are biomechanically more stable than non-locking plates and they can even maintain the anatomy of dorsally displaced distal radius fractures.[15,16] The purpose of this study is to find the functional outcome of volar locking plates in the treatment of unstable distal radius in our setup.

METHODS

This prospective study was conducted at Chitwan Medical College. From September 2016 to April 2017, fifty two patients with unstable distal radius fractures were treated with volar locking plate. They were followed up for a minimum of one year. Three

patients were lost to follow-up, three patients had other ipsilateral upper limb injury and one was a case of polytrauma. Forty-five patients were thus included in the study. An unstable distal radius fracture was defined as a distal radius fracture with dorsal angulation >15°, extensive metaphyseal comminution, radial shortening of >5mm or an intra-articular step off > 2mm. Patients with previous injury to the wrist, associated other fractures in the same upper limb and those treated with dorsal plating or external fixation in addition to the volar plate were excluded.

Approval for the study was granted from the Hospital Ethical Committee and informed consent was taken from all the participants.

There were 23 men and 22 women in our study with age ranging from 15-75 years (mean 43.22 years). The average follow-up period was 16.53 months (range 12-20 months). The most common mechanism of injury was fall from a standing height (19 patients) (Table 1). According to the AO classification of fractures, there were 17 type A fractures (5 A2, 12 A3), 11 type B fractures (3 B1, 1 B2, 7 B3), and 18 type C fractures (4 C1, 12 C2, 2 C3).

Surgery was performed under brachial plexus block in 36 cases and general anaesthesia in 9 cases. An upper arm tourniquet was used in all cases except for one who had bilateral involvement. The distal radius was exposed using a volar approach along the flexor carpi radialis tendon. After the skin incision, the forearm fascia was incised along the radial border of flexor carpi radialis and the pronator quadratus muscle was released from its radial insertion to reach the fracture site. After reduction of the fracture, a 3.5mm titanium volar locking plate was placed and a screw fixed at the central oval hole. Fracture reduction and optimal plate placement was checked with the image intensifier. Remaining screws were then placed. No bone graft was used in any cases. Carpal tunnel was released in two cases. The pronator quadratus muscle was not repaired. Closure was done under a suction drain to be removed on second post-operative day. No splintage was used in twenty nine cases, and in remaining cases a below-elbow slab was used for 2 weeks till the time of sutures removal.

Active range of motion was allowed immediately as tolerated by the patient. Physiotherapist assisted active motion of the wrist was begun at 2 weeks and passive range of motion was started at 6 weeks.

Follow-up evaluation was performed at 6 weeks, 3 months, 6 months and 1 year. Radiological evaluation was done measuring the palmar tilt, radial inclination, radial height and ulnar variance. Union of the fracture was defined as bony bridging across the fracture site. Functional outcome was measured using the Cooney modification of the Green and O'Brien score 17 (Table 2) – four parameters pain, functional status, range of motion and grip strength; each given a weightage of 25 points, giving a total score of 100. Final rating is done as follows: excellent 90-100, good 80-89, fair 65-79, and poor <65 points.

RESULTS

We evaluated 45 patients with 46 fractures. The mean time for union was 7.96 weeks (range 6-12 weeks). The final outcome using modified Green and O'Brien Score was 20 excellent, 15 good, 7 fair and 4 poor results. The good to excellent result was 76.1%.

In the initial post-operative period, the average radial height was 11.37 mm, radial inclination 20.460 and volar tilt 6.240. There was negative ulnar variance of -0.5 ± 1.38 mm. At the final follow-up, the average radial height, inclination and tilt were 11.05 mm, 19.960 and 6.390 respectively. The decrease in radial height and radial inclination from post-operative to final follow-up period was statistically significant ($p<0.05$, Table 3).

At the final follow-up, average wrist flexion was 62.39 ± 16.01 degrees (range, 30 to 80 degrees), extension 53.04 ± 17.62 degrees (range, 10 to 80 degrees), forearm supination 77.83 ± 12.05 degrees (range, 30 to 90 degrees) and pronation 80.11 ± 14.16 degrees (range, 20 to 90 degrees). The average grip strength was 76.94 ± 15.63 % of the contralateral side.

The overall complication rate was 15.22%. Early complications included one wound dehiscence managed with debridement and re-suturing, one superficial infection treated with oral antibiotics, two patients had complex regional pain syndrome (CRPS) which improved with physiotherapy, and one

patient developed tingling sensation in the median nerve distribution which improved with time. There were no deep seated infection and all the fractures united. One patient had rupture of flexor pollicis longus (FPL) tendon that underwent implant removal and tendon reconstruction. There was one case on breakage of single screw.

TABLES

Table 1: Baseline characteristics of patients

Variables	
Male/Female, n	23/22
Mean (SD*) age, year	43.22(19.85)
Mechanism of injury. n	
Fall from standing height	19
Fall from height > 5 feets	9
Road Traffic Accident	15
Spors related	2
Affected hand (right/left/bilateral)	17/27/1
Dexterity (right/left)	43/2
Mean follow-up duration, months	16.53

**Standard Deviation*

Table 2: Clinical scoring- Green and O'Brien Score (Cooney modification)

Pain (25 points)
25 None
20 Mild, occasional
15 Moderate, tolerable
0 Severe or intolerable
Range of motion (25 points): flexion + extension, percentage of normal
25 100
15 75-99
10 50-74
5 25-49
0 0-24
Dorsiflexion-palmarflexion arcs if only injured hand reported
25 1200 or more
15 900-1200
10 600-900
5 300-600
0 300 or less
Grip strength (25 points), percentage of normal
25 100

15	75-99
10	50-74
5	25-49
0	0-24
Activities (25 points)	
25	Returned to regular employment
20	Restricted employment
15	Able to work but unemployed
0	Unable to work because of pain

Table 3: Radiological parameters during follow-up

Variables	Post-op*	Final follow-up*	Difference*	p-value†
Radial height	11.37 ± 2.85 mm	11.05 ± 3.06 mm	0.32 ± 0.54 mm	0.000
Radial inclination	20.460 ± 3.910	19.960 ± 4.290	0.500 ± 0.690	0.000
Volar tilt	6.240 ± 5.200	6.390 ± 4.920	-0.150 ± 0.600	0.090

**Mean ± Standard Deviation*
†Paired-samples t-test

DISCUSSION:

Various surgical options are available for management of distal radius fractures with an aim to achieve and maintain anatomical reduction. Various studies have shown volar fixed-angle locking plates to be biomechanically superior.[15, 18]

We used the volar approach to distal radius as described by Chung et al.[19] The pronator quadratus muscle was not repaired. Bone grafting was not done. Arora et al [20] achieved good functional results without using bone graft. Routine release of carpal tunnel was not done as there is no evidence on the noticed benefit of prophylactic carpal tunnel decompression in the literature.[21] The associated ulnar styloid fracture was not fixed. Zenke et al [22] concluded that the presence of associated ulnar styloid fracture does not adversely affect the outcome in patients with a fracture of distal radius treated by volar plating.

The mean age of patients in our study was 43. 22 years which is comparable to a similar study conducted in Nepal by Pradhan et al [23] 42.53 years. Other studies had a higher mean age- 53 years Rozental et al,[24] 57.4 years Arora et al 20 and 62 years Drobetz et al.[25] This may be due to higher life expectancy in these countries.

Males were affected more in our study as well in other studies by Pradhan et al[23] and Drobetz et al.[25] Female preponderance was seen in studies of Arora et al and Rozental et al.[20,24] Males were affected more in the age group <40 years (M:F = 1.9:1), and this may be because males are more involved in outdoor activities and are thus more prone to trauma. There was female predominance in age group >= 40 years (M:F = 1:1.5), which may be because their bones are more osteoporotic post-menopause with increased the risk of fracture with trivial trauma like fall. The most common mechanism of injury was fall from standing height (42.22%) as was the case with Arora et al (75.44%)[20] and Rozental et al (80.49%).[24] In our study the average time for union was 7.96 weeks which is similar to Pradhan et al[23] (8 weeks). Earlier union at 7 weeks was seen in studies of Arora et al,[20] Wright et al[26] and Orbay et al.[9]

According to modified Green and O'Brien Score we had 76% excellent to good results (43.48% excellent, 32.61% good). This is similar to study by Arora et al 74% (27.19% excellent, 47.37% good, n=114).[20]

Drobetz et al had 68% results (46% excellent, 22% good, n=50).[25] However Pradhan et al had upto 96.67% results (76.67 excellent, 20% good, n=30).[23] Assessment of radiological parameters showed a decrease in radial height of 0.32 ± 0.54 mm, radial inclination 0.500 ± 0.690 and radial tilt -0.150 ± 0.600 from postoperative period to final follow-up, the final follow-up values being 11.05 mm, 19.960 and 6.390 respectively. In the study of Arora et al,[20] there was a mean loss of palmar tilt of 3.40 ± 4.90 and radial inclination of 0.40 ± 1.[20] Rozental et al[24] had an average radial height of 11.1mm, inclination 210 and tilt 40 in the initial postoperative period, and at the time of fracture union 11mm, 210 and 50 respectively. The mean radial inclination was 220 and volar tilt 100 at final follow-up in the study of Wright et al.[26]

Assessment of active range of motion showed that all the patients had an arc of motion greater than 400 in flexion/extension (average 1150) and greater than 500 forearm rotation (average 1580). The average range of motion consisted of 620 of flexion, 530 of extension, 780 of supination and 800 of pronation. In the similar studies the average ranges of motion were- 450 flexion, 540 extension, 820 supination and 810 pronation (Arora et al);[20] 520 flexion, 530 extension, 710 supination and 730 pronation (Rozental et al);[24] 550 flexion, 580 extension, 760 supination and 800 pronation (Orbay et al)[9] and 640 flexion, 630 extension, 800 supination and 780 pronation (Wright et al).[26]

The average grip strength was 77% of the contralateral side in our study, and this was similar to other studies- 75% Wright et al[26] and 77% Orbay et al.[9] Other studies had a lower (70% of the contralateral side, Arora et al)[20] or a higher (94%, Rozental et al)[24] grip strength than our study.
The overall complication rate was 15.22% - two CRPS (4.35%) and one (2.17%) each superficial infection, wound dehiscence, median nerve neuropathy, FPL tendon rupture and screw breakage. Higher complication rates were seen in studies of Rozental et al (22%, n=9), Arora et al (27%, n=31) and Drobetz et al (32%, n=16).[20, 24, 25]Rozental et al[24] had 3 cases of tendon irritation (7.32%) and 1 metacarpophalangeal joint stiffness (2.44%). Arora et al[20] had 17 (15%) tendon complications- 13 tenosynovitis (12%) and 4 tendon rupture (4%). There were 5 cases of CRPS (4%), 3 carpal tunnel syndrome (3%) and 2 screw loosening (2%). Drobetz et al[25] had 7 tendon ruptures (14%), 3 CRPS (6%), 2 infections (4%), 1 carpal tunnel syndrome (2%) and 1 screw loosening (2%). Pradhan et al[23] had only 10% complications- 2 superficial infection and 1 screw penetration into joint. No nonunion was seen in any of these studies as was the case in our study.

CONCLUSION

Volar locking plates can be used to treat unstable distal radius fractures with sufficient stability and provide good to excellent results in many cases. Careful intraoperative fluoroscopy may prevent screw penetration into the joint and the correct screw length will prevent extensor tendon irritation.

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FIGURES

Figure 1 Preoperative radiographs (anteroposterior and lateral views) of fracture distal radius, frontal, volar rim

Figure 2 Postoperative radiographs (anteroposterior and lateral views) showing fixation with volar locking plate

Figure 3 Radiographs (anteroposterior and lateral views) at one year follow-up

Figure 4 Clinical photographs at 18 months follow-up showing excellent results (affected side left)

LEGEND FOR FIGURES

Figure 1 Preoperative radiographs (anteroposterior and lateral views) of fracture distal radius, frontal, volar rim

Figure 2 Postoperative radiographs (anteroposterior and lateral views) showing fixation with volar locking plate

Figure 3 Radiographs (anteroposterior and lateral views) at one year follow-up

Figure 4 Clinical photographs at 18 months follow-up showing excellent results (affected side left)