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Comparison of the Outcomes of Treatment on Comminuted Distal Radius Intraarticular Fracture by Volar Locking Plate Fixation and External Fixator

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Abstract **Original Research Article**

Introduction: Intra-articular fractures of the distal radius represent high-energy, complex, unstable injuries. An anatomical reduction of the joint surface with rigid fixation is the main goal in the treatment of intra-articular distal radial fractures, but the optimal method of treatment remains controversial. The treatment strategies to achieve anatomical reduction for intra-articular fractures and possible surgical treatment methods are external fixation and open reduction and internal fixation (ORIF) by volar locking plate has become increasingly popular. This study aimed to analyze a comparison of the outcomes of treatment on comminuted distal radius intraarticular fracture by volar locking plate fixation and external fixator. ***Methods:*** This cross-sectional comparative study was conducted in the Department of Orthopedics, Sylhet M A G Osmani Medical College Hospital, Sylhet during the period from 1st July 2014 to 30th June 2016. A total of 24 cases of a distal radial comminuted intra-articular fracture. They were divided by random allocation into group-A and group B each comprising 12 patients. Every odd number of patients was taken as group-A and an even number of patients was taken as group B. The patients of group-A were treated with a volar locking plate and patients of group B were treated with an external fixator. ***Result:*** The age of the patients ranged from 21 to 50 years with a mean age of 33.7 (SD 9.4) years in group-A; while it was 25 to 60 years and 37.1 (SD 9.2) years respectively in group B. Outcome was measured using Quick DASH score and it was significantly lower in group-A than that of group-B [16.9 (SD 1.1) versus 21.5 (SD 4.5); t=-3.428; p<0.01). The outcome was also measured using O'Brien scoring system. The recorded Green O'Brien scoring score was significantly higher in group-A than that of group B [86.7 (SD 6.9) versus 77.9 (SD 10.3); t=2.446; p<0.05). There were 4 (33.3%) excellent, 7 (58.3%) good, and 1 (8.3%) fair in group-A; whereas 3 (25.0%) excellent, 5 (41.7%) good, and 4 (33.3) fair in group B. ***Conclusion:*** We conclude that volar locking plate fixation has a better outcome than that of an external fixator for distal radius intra-articular fracture.

Keywords: Radius, Fracture, External fixator, Volar locking plate fixation.

INTRODUCTION

Distal radius fractures (DRFs) represent the most common type of fracture in the upper extremity and pose a serious public health concern. Increasing life expectancy, population aging, and subsequent increases in osteoporosis have resulted in the rising incidence of DRFs, with reports of 17% to 100% increases over the past 3 to 4 decades [1]. Fractures of the distal radius usually occur as a result of high-energy trauma in the younger individual with good bone density and are associated with substantial articular and periarticular tissue injury. Besides, these fractures are also reported in elderly osteoporotic patients [2]. Distal radius fractures are almost always within an inch of the wrist joint and may extend into the joint. High-energy fractures of the distal part of the radius with extensive comminution of the articular surface and extension into the diaphysis represent a major treatment challenge. Unlike the more common, low-energy, extra-articular fractures; intraarticular distal radius fractures represent a complex injury that is associated with considerable morbidity (intractable wrist pain, joint stiffness, reduced range of motion). Generally, the prognosis is less favorable for displaced, comminuted, intraarticular fractures. The primary reason behind these less favorable outcomes is attributed to problems restoring and maintaining an anatomic reduction of the articular surface. [3] The radiological anatomy of the distal radioulnar joint is very much important to know the reason why wrist disability occurs after distal radius fracture and the necessity of acceptable reduction of the fracture. The radial inclination ranges from 13^0 to 30^0 with an average is around 23^0 [4]. Loss of radial inclination will increase the risk of the development of chronic pain. Palmar or volar tilt is average around 11^0. For patients with greater than 15 degrees of dorsal angulations, the result is unsatisfactory in that grip strength [3]. Radial length or height averages 10-13 mm. Loss of radial height is a predictor of a less favorable outcome in distal radial fractures. Radial Length shortening results from extensive comminution and impaction of fracture fragments into the metaphysis leading to severe wrist pain. [4] There is both consensus and scientific evidence that restoration of the anatomy of the distal radius is closely linked to the restoration of function. Consequently, closed or operative management should seek to restore: 1) Articular congruity (to reduce the wear of articular cartilage and degenerative changes), 2) Radial alignment and length (to restore kinematics of the carpus and radioulnar joint), 3) Motion (digits, wrist, and forearm to optimize return to functional activities), 4) Stability (to preserve length and alignment until healing of the fracture. Treatment options for distal radius fractures are closed reduction, percutaneous pin fixation, external fixation, augmented external fixation, arthroscopic reduction, and percutaneous fixation, open reduction and internal fixation, fragment-specific fixation, distraction plating. [5] To reduce the incidence of posttraumatic arthrosis and to guarantee a successful functional outcome, there has been a trend toward more aggressive fracture fixation in patients with a DRF [6, 7]. During the last decade, there has been a shift in the strategy for treating intraarticular distal radius fractures toward internal fixation and volar locking plate fixation (VLP) and Volar plates (VP) have gained popularity because of their low complication rates and high stability in osteoporotic bone without joint distraction [8, 9]. Several studies have demonstrated that open reduction internal fixation (ORIF) is superior to external fixation (EF) in the short term and some studies reported a tendency toward overall better Quick Disabilities of the Arm, Shoulder, and Hand (Quick DASH) scores by the 12-month follow-up after using VLP [10-15]. This study aimed to analyze a comparison of the outcomes of treatment on comminuted distal radius intraarticular fracture by volar locking plate fixation and external fixator.

OBJECTIVE

General Objective

- To compare the outcome of the volar locking plate system and uniaxial external fixator system for the operative treatment of distal radius intraarticular fracture (AO type C3).

Specific Objectives

- To record and compare the duration of operation time between the volar locking plate system and uniaxial external fixator system for the treatment of distal radius intraarticular fracture (AO type C3).
- To record and compare the post-operative range of motion (ROM) of the wrist joint between two techniques of fixation.
- To record and compare the anatomical restoration (radiologically) of broken distal radius between two techniques of fixation.
- To record and compare the hand grip strength between two methods of fixation.
- To record and compare pain measured by visual analogue scale (VAS) between two techniques of fixation.
- To record and compare the union of fracture site and complications between two techniques of fixation.
- To record and compare the functional outcome of both methods by Quick DASH (Disabilities of the arm shoulder and hand) symptom scale.
- To compare the functional outcome of both methods by Green O'Brien scale.

METHODS

This cross-sectional comparative study was conducted in the Department of Orthopedics, Sylhet M A G Osmani Medical College Hospital, Sylhet during the period from 1st July 2014 to 30th June 2016. A total of 24 cases of a distal radial comminuted intra-articular fracture. After taking informed written consent patients were divided by random allocation into group-A and group B each comprising 12 patients. Every odd number of patients was taken as group-A and an even number of patients was taken as group B. The patients of group-A were treated with a volar locking plate and patients of group B were treated with an external fixator**.** Data were processed and analyzed both manually and using SPSS (Statistical Package for Social Sciences) Version 21.0. Ethical clearance was obtained from the Institutional Ethical Committee of Sylhet M A G Osmani Medical College.

Inclusion Criteria

- All patients with distal radius intraarticular comminuted fracture.

- Patients of age 18- 55 years
- Patients of both sexes.
- Patients who had given consent to participate in the study.

Exclusion Criteria

- Patients with open fractures
- Patients with a previously operated or nonfunctional wrist.
- Patients with associated carpal bone fracture
- Patients who did not give consent to participate in the study.

RESULTS

The age of the patients ranged from 21 to 50 years with a mean age of 33.7 (SD 9.4) years in group-A; while it was 25 to 60 years and 37.1 (SD 9.2) years respectively in group B (Table 1). Males were predominantly affected by distal radial articular fracture [9 (75.0% versus 7 (58.3%)]. The sex difference between the patients of group-A and group B did not show any statistically significant difference (Table 2). In this study, 8 (66.7%) patients had the cause of injury in distal radial articular fracture was a road traffic accident (RTA), and in the remaining 4 (33.3%) patients, the cause of injury was an assault in group-A. It was 7 (58.3%) and 5 (41.7%) patients respectively in group B (Table 3). The operation time ranged from 50 to 75 minutes with the mean of 60.8 (SD 7.6) minutes in group-A; while it was 25 to 40 minutes and 29.2 (SD 5.6) minutes respectively in group-B. The operation time was significantly longer in group A than that in the group (t=11.602; p<0.01). In group–A operation time was 46-60 minutes in 9 (75.0%) patients and above 60 mutes in 3 (25.0%) patients; whereas in group B operation time was up to 30 minutes in 10 (83.3%) patients and 31-45 mutes in 2 (16.7%) patients. Operation time between the two treatment groups differed significantly (Table 4). Mean pain score at 3 weeks was almost similar in both treatment groups [2.7 (SD 1.1) versus 3.3 (SD 1.3); t=-1.368; p>0.05]. At 3 weeks follow up 9 (75.0%) patients experienced mild pain and 3 (25.0%) patients experienced moderate pain in group-A. It was 8 (66.7%) and 4 (33.3%) patients respectively in group B. Pain at 3 weeks. Range of motion in the wrist joint was 36.6 (SD 12.1) degree flexion in 47.9 (SD 11.0) degree extension recorded only in group-A. Grip strength was significantly higher in group-A than that of group B [23.0 (SD 2.9) percent versus 13.0 (SD 2.3) percent; t=9.351; p<0.01] Radial deviation 11.3 (SD 3.1) degree and ulnar deviation 16.3 (SD 4.8) degree were recorded only in group-A. Volar tilt [13.1 (SD 2.4) degree versus 13.7 (SD 2.3) degree; t=0.738; p>0.05); radial inclination [19.5 (SD 2.8) degree versus 18.6 (SD 3.2) degree; t=-0.571; p>0.05) and radial height [10.8 (SD 1.8) mm versus 9.3 (SD 3.6) mm; t=1.283; p>0.05). Articular step-off was congruent in 11 (91.7%) patients and incongruent in 1 (8.3%) patient in group-A; while articular step-off was congruent in 8 (66.7%) patients and incongruent in 4 (33.3%) patients in group-B (Table 5). Mean pain score at 6 weeks was almost similar in both treatment groups [2.4 (SD 0.9) versus 3.1 (SD 1.2); t=-1.569; p>0.05]. At 6 weeks follow up 11 (91.7%) patients experienced mild pain and 1 (8.3%) patient experienced moderate pain in group-A; while 8 (66.7%) and 4 (33.3%) respectively in group B. Range of motion (ROM) in the wrist joint of flexion [62.9 (SD 8.4) degree versus 47.9 (SD 6.2) degree; t=4.984; p<0.01] and extension [57.1 (SD 11.0) degree versus 31.2 (SD 9.1) degree; t=4.984; p<0.01]. Grip strength was significantly higher in group-A than that in group B [33.4 (SD 1.5) percent versus 21.6 (SD 2.0) percent; t=16.542; p<0.01] Radial deviation was significantly higher in group-A than that of group B [15.8 (SD 4.2) degree versus 6.7 (SD 2.5) degree; t=6.553; p<0.01] but ulnar deviation did not differ significantly between two treatment group [27.9 (SD 4.5) degree versus 29.6 (SD 4.0) degree; t=0.962; p<0.01]. Volar tilt [13.1 (SD 2.4) degree versus 13.7 (SD 2.6) degree; t=-0.571; p>0.05); radial inclination [19.5 (SD 2.8) degree versus 18.7 (SD 3.0) degree; t=0.626; p>0.05) and radial height [10.7 (SD 1.8) mm versus 9.2 (SD 3.6) mm; t=1.379; p>0.05). Articular step-off was congruent in 11 (91.7%) patients and incongruent in 1 (8.3%) patient in group-A; while articular step-off was congruent in 8 (66.7%) patients and incongruent in 4 (33.3%) patients in group-B (Table 6). Mean pain score at 12 weeks was almost similar in both treatment groups [0.3 (SD 0.8) versus 1.1 (SD 1.4); t=-1.641; p>0.05]. At 12 weeks follow up 10 (83.3%) patients experienced no pain and 2 (16.7%) patients experienced mild pain in group-A; while 7 (58.3%) and 5 (41.7%) respectively in group B. Range of motion (ROM) in wrist joint of flexion [71.2 (SD 6.1) degree versus 71.7 (SD 3.3) degree; t=-0.209; p>0.05] and extension [69.2 (SD 7.3) degree versus 65.0 (SD 5.2) degree; t=1.603; p>0.05] Grip strength was significantly higher in group-A than that of group-B [60.0 (SD 1.18) percent versus 49.0 (SD 1.8) percent; t=15.230; p<0.01]. Radial deviation was significantly higher in group-A than that in group B [17.9 (SD 3.3) degrees versus 13.3 (SD 3.9) degrees; t=3.094; p<0.01] but ulnar deviation did not differ significantly between the two treatment groups [32.5 (SD 3.4) degree versus 34.2 (SD 1.9) degree; t=-1.483; p>0.05]. Volar tilt [13.1 (SD 2.4) degree versus 14.5 (SD 3.4) degree; t=1.181; p>0.05); radial inclination [19.5 (SD 2.8) degree versus 18.1 (SD 3.0) degree; t=-1.181; p>0.05) did not differ significantly between two treatment group. But radial height [10.8 (SD 1.8) mm versus 8.3 (SD 3.8) mm; t=2.049; p<0.05) was significantly higher in group-A than that group B. Articular step-off was congruent in 11 (91.7%) patients and incongruent in 1 (8.3%) patient in group-A; while articular step-off was congruent in 7 (58.3) patients and incongruent in 5 (41.7) patients in group-B (Table 7). The recorded complications were intra articular screw in 2 (16.7%) patients in group-A; while pin tract infection was developed in 2 (16.7%) patients and over distraction in 1 (8.3%) patient in group B (Table 8). Outcome was measured using Quick DASH score and it was significantly lower in group-A than that of group-B [16.9 (SD 1.1) versus 21.5 (SD 4.5); t=-3.428; p<0.01). The outcome was also measured using O'Brien scoring system. The recorded Green O'Brien scoring score was significantly higher in group-A than that of group B [86.7 (SD 6.9) versus 77.9 (SD 10.3); t=2.446; p<0.05). There were 4 (33.3%) excellent, 7 (58.3%) good, and 1 (8.3%) fair in group-A; whereas 3 (25.0%) excellent, 5 (41.7%) good, and 4 (33.3) fair in group B (Table 9).

Table 1: Distribution of patients according to age, (N=24)

Age (years)	Study group		p-value
	Group-A (n=12) Frequency	Group B (n=12) Frequency	
21-30	5	4	p>0.05
31-40	4	5	
41-50	3	2	
51-60	0	1	
Mean	33.7 (SD 9.4)	37.1 (SD 9.2)	p>0.05

Table 2: Distribution of patients according to sex, (N=24)

Sex	Study group		p-value
	Group-A (n=12) Frequency	Group B (n=12) Frequency	
Male	9	7	p>0.05
Female	3	5	
Total	12	12	

Table 3: Distribution of patients according to the cause of injury, (N=24)

Cause of injury	Study group		p-value
	Group-A (n=12) Frequency	Group B (n=12) Frequency	
RTA	8	7	p>0.05
Assault	4	5	
Total	12	12	

Table 4: Distribution of patients by operation time, (N=24)

Operation time (min)	Study group		
	Group-A (n=12) Frequency	Group B (n=12) Frequency	p-value
≤30	0	10	p<0.01
31-45	0	2	
46-60	9	0	
>60	3	0	
Mean	60.8 (SD 7.6)	29.2 (SD 5.6)	p<0.01

Table 5: Distribution of patients by follow-up findings at 3 Weeks, (N=24)

Parameters		Study group		P value
		Group-A (n=12) Frequency	Group B (n=12) Frequency	
Pain				
	Mild	9	8	p>0.05
	Moderate	3	4	
	Mean	2.7 (SD 1.1)	3.3 (SD 1.3)	p>0.05
ROM of wrist				
	Flexion (^{0})	36.6 (SD 12.1)		
	Extension (^{0})	47.9 (SD 11.0)		
Grip strength (%)		23.0 (SD 2.9)	13.0 (SD 2.3)	p<0.01
Radial deviation (^{0})		11.3 (SD 3.1)		
Ulnar deviation (^{0})		16.3 (SD 4.8)		
Volar tilt (^{0})		13.1 (SD 2.4)	13.7 (SD 2.3)	p>0.05

Radial inclination (^{0})		19.5 (SD 2.8)	18.6 (SD 3.2)	p>0.05
Radial height (mm)		10.8 (SD 1.8)	9.3 (SD 3.6)	p>0.05
Articular step-off				
	Congruent	11	8	p>0.05
	Incongruent	1	4	

Table 6: Distribution of patients by follow-up findings at 6 weeks, (N=24)

Parameters		Study group		P value
		Group-A (n=12) Frequency	Group B (n=12) Frequency	
Pain				
	Mild	11	8	p>0.05
	Moderate	1	4	
	Mean	2.4 (SD 0.9)	3.1 (SD 1.2)	p>0.05
ROM of wrist				
	Flexion (^{0})	62.9 (SD 8.4)	47.9 (SD 6.2)	p<0.01
	Extension (^{0})	57.1 (SD 11.0)	31.2 (SD 9.1)	p<0.01
Grip strength (%)		33.4 (SD 1.5)	21.6 (SD 2.0)	p<0.01
Radial deviation (^{0})		15.8 (SD 4.2)	6.7 (SD 2.5)	p<0.01
Ulnar deviation (^{0})		27.9 (SD 4.5)	29.6 (SD 4.0)	p>0.05
Volar tilt (^{0})		13.1 (SD 2.4)	13.7 (SD 2.6)	p>0.05
Radial inclination (^{0})		19.5 (SD 2.8)	18.7 (SD 3.0)	p>0.05
Radial height (mm)		10.7 (SD 1.8)	9.2 (SD 3.6)	p>0.05
Articular step-off (mm)				
	Congruent	11	8	p<0.05
	incongruent	1	4	p>0.05

Table 7: Distribution of patients by follow-up findings at 12 weeks, (N=24)

Parameters		Study group		
		Group-A (n=12) Frequency	Group B (n=12) Frequency	P value
Pain				
	No pain	10	7	p>0.05
	Mild	2	5	
	Mean	0.3 (SD 0.8)	1.1 (SD 1.4)	p>0.05
ROM of wrist				
	Flexion (^{0})	71.2 (SD 6.1)	71.7 (SD 3.3)	p>0.05
	Extension (^{0})	69.2 (SD 7.3)	65.0 (SD 5.2)	p>0.05
Grip strength (%)		60.0 (SD 1.18)	49.0 (SD 1.8)	p<0.01
Radial deviation (^{0})		17.9 (SD 3.3)	13.3 (SD 3.9)	p<0.01
Ulnar deviation (^{0})		32.5 (SD 3.4)	34.2 (SD 1.9)	p>0.05
Volar tilt (^{0})		13.1 (SD 2.4)	14.5 (SD 3.4)	p>0.05
Radial inclination (^{0})		19.5 (SD 2.8)	18.1 (SD 3.0)	p>0.05
Radial height (mm)		10.8 (SD 1.8)	8.3 (SD 3.8)	p<0.05
Articular step-off				
	Congruent	11	7	p>0.05
	Incongruent	1	5	

Table 8: Distribution of patients by complications, (N=24)

Complications	Study group		p-value
	Group-A (n=12) Frequency	Group B (n=12) Frequency	
Intra articular screw	2	0	p>0.05
Pin tract infection	0	2	
Over distraction	0	1	
No complication	10	9	

Table 9: Distribution of Patients by Outcome

Outcome		Study group		p-value
		Group-A (n=12) (Volar plating) Frequency (%)	Group B (n=12) (Ex-Fix) Frequency (%)	
Quick DASH		16.9 (SD 1.1)	21.5 (SD 4.5)	p<0.01
Green O'Brien scoring				
	Excellent	4 (33.3)	3 (25.0)	p>0.05
	Good	7 (58.3)	5 (41.7)	
	Fair	1 (8.3)	4 (33.3)	
	Poor	0 (0.0)	0 (0.0)	

Discussion

In this study, the age of the patients ranged from 21 to 50 years with a mean age of 33.7 years in the volar plating group; while it was 25 to 55 years and 37.1 years respectively in the external fixator group. The age of the patients did not differ significantly between the two groups. This result was nearly similar to another study in that the mean age of the patients with displaced intra-articular distal radius fractures was 39.33 ± 13.1 years in the volar plate group and 38.95 ± 13.15 years in the external fixation group [16]. Another study reported male predominance of distal radial articular fracture (58.9%) treated with the volar plate [17]. The current study demonstrated that the cause of injury in distal radial articular fracture was a road traffic accident in 66.7% of patients in the volar plating group and remaining 33.3% of patients, the cause of injury was assault. It was 58.3% and 41.7% respectively in group B. Another study reported that the mode of injury was a road traffic accident (48%), fall (36%), and physical assault (16%) [18]. In the present study, the operation time ranged from 25 to 40 minutes with a mean of 60.8 (SD 7.6) minutes in the volar plating group; while it was 50 to 75 minutes and 29.2 (SD 5.6) minutes respectively in the external fixator group. The operation time was significantly longer in group A than in that of the group (p<0.01). This result was almost similar to another study where the mean surgery time was 56.5 ± 2.7 minutes in the volar plate fixation group and 35.1 ± 2.5 in the external fixation group; the difference was significant [20]. In the current study the range of motion (ROM) in the wrist joint of flexion [62.9 (SD 8.4) degree versus 47.9 (SD 6.2) degree; p<0.01] and extension [57.1 (SD 11.0) degree versus 31.2 (SD 9.1) degree; p<0.01] were significantly higher volar plating group than that of external fixator group at six weeks follow up. Another study found that the range of motion in the wrist joint of flexion did not differ significantly between the volar plate group and the external fixator group at six weeks follow-up, but extension was significantly higher in the volar plate group compared to the external fixator group at six weeks follow up. In the current study articular step-off was congruent in 11 (91.7%) patients and incongruent in 1 (8.3%) patient in the volar plating group; while articular step-off was congruent in 8 (66.7%) patients and incongruent in 4 (33.3%) patients in external fixator group; the difference was not statistically significant (p>0.05) at six weeks follow up. A study reported that step deformity did not differ significantly between the volar plate group and the external fixator group at six weeks of follow-up [21]. In the present study volar tilt [13.1 (SD 2.4) degree versus 14.5 (SD 3.4) degree; p>0.05) at 12 weeks follow up. This result was consistent with another study which showed no significant differences in volar tilt between the volar plating and external fixator groups at 12 weeks of follow-up [1]. In the present study, the recorded complications were one intra articular screw in 16.7% of patients in the volar plating group; while pin tract infection was developed in 16.7% of patients and over distraction in 8.3% of patients in the external fixator group. The recorded complications did not differ significantly between the two treatment groups (p>0.05). In this regards a study reported that 6.66% of patients had screw impingement and 10% of patients had developed stiffness in the volar plate group; while 13.33% of patients had stiffness, 10% of patients had collapse of the fracture segment, and 6.66% patients developed features of reflex sympathetic dystrophy [22]. A study found that the DASH score was significantly lower in the volar plating group than that of the external fixator group which is quite similar to this study [23]. The outcome was also measured using the Green and O'Brien scoring system in the present study. In this regards a study reported that the outcome was excellent in 45.5%, good in 45.5%, and fair in 9% in their series of intraarticular fracture distal radius treated with locking compression volar plate which was relatable to this study.

Limitations of The Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community. The patient's functional baseline state, a potential factor influencing the recovery process, could not be examined because all patients presented after sustaining a fracture.

Conclusion

This study concluded that volar locking plate fixation is better than external fixators in intra-articular distal radius fractures.

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Conflict of interest: None declared.

Ethical approval: The study was approved by the Institutional Ethics Committee.

Recommendation

The present study recommends volar locking plate fixation as the choice in intra-articular distal radius fractures. Moreover, further studies should be carried out involving a large sample size and multiple centers in this regard.

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