Functional Evaluation of Surgical Fixation of Distal Radius Fractures

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ABSTRACT

BACKGROUND

Distal radius fracture is the most common orthopaedic injury in adults. It has an approximate incidence of 1:10,000 people and 16 % are of skeletal and 74 % of forearm fractures. Many fractures of the distal radius are relatively uncomplicated and can be effectively managed with closed reduction and immobilization in a cast. Over the past twenty years, more sophisticated internal and external fixation techniques and devices for the treatment of distal radius fractures have been developed keeping up with the demands of the modern day. Functional outcome seems to follow the surgical treatment which results in more anatomical results.

METHODS

A total of thirty (n = 30) distal radial fractures were treated surgically by various methods at Government General Hospital, Kakinada. They were evaluated functionally with Quick Dash score at one and half, 3 and 6 months duration. Twenty cases were treated with a volar plate through Henry's approach. Six cases were treated with per cutaneous k wire fixation and four cases were treated with forearm external fixator application (Ligamentotaxis). Final outcome was evaluated by QUICK DASH evaluation questionnaire. In each patient Quick Dash score were taken at 6 weeks, 3 months & 6 months interval along with range of motion at 6months interval up to 2 years.

RESULTS

There were 22 (73.3 %) males and 8 (26.6 %) females. The age group ranged between 15 - 80 years. Eleven (36.6 %) patients had right side involvement. Nineteen (63.3 %) had left side involvement. Of the 30 cases, mode of injury was fall on outstretched hand in 21 (70 %) patients and road traffic accident in 9 (30 %) patients. Functional outcome correlated positively with the degree of anatomical reduction.

CONCLUSIONS

Functional outcome correlated positively with the degree of radial length, volar tilt and radial inclination achieved when compared to normal side. The method of internal fixation with volar locking plate appears to be favoured by many akin to its ability to sustain the reduction. Comminuted intra articular fractures fared less well with more number of complications. However, fracture union time seems to be unaffected by the method of fixation.

KEYWORDS

Radius A02.835.232.087.090.700, Orthopaedic Procedures E02.718, Range of Motion, Articular E01.370.600.700

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BACKGROUND

Distal radius fractures were the most frequent fractures encountered in humans. They impose considerable work load on orthopaedic surgeons all over the world. In many population based studies, distal radius fractures incidence rates vary from 5.7 to 124.6 per 10,000 person years. It shows bimodal age distribution with two peaks, one at 5 - 14 years of age and the other above 60 years. Elderly females are more prone to fracture with a male to female ratio of 1:4. Biomechanical experiments show that distal radius fractures when the wrist was loaded in 40^0 - 90^0 of dorsiflexion and 0^0 - 35^0 of either ulnar or radial deviation. With a fall on the "outstretched hand", the radius gets loaded through rigidly bonded carpus and bears the force transmitted through the thenar muscle mass. Fracture line starts volarly (tension side) then extends to the dorsal cortex where the bending moment induces compression stress resulting in a comminution dorsally or producing a fracture line at 45^0 to the long axis of the radius.

We wanted to assess the functional outcome of fracture distal radius treated by various surgical methods along with their advantages and complications.

METHODS

A prospective observational study conducted on thirty (n = 30) adult persons suffering from distal radius fractures treated at Department of Orthopaedics, Government General Hospital affiliated to Rangaraya Medical College, Kakinada, from September 2016 to September 2018. Patients were managed with ORIF (Open Reduction and Internal Fixation) using Ellis plate, percutaneous K wires and external fixator application. All the operations were done under antibiotic cover. Either general anaesthesia or brachial block was used as anaesthetic technique. Radiographs in postero-anterior and lateral views were performed. Oblique views were ordered to patients with high complexity of fractures. The fracture morphology was studied, and involvement of radio carpal and distal radio ulnar joints were assessed. Fractures were classified using the Frykman's classification of distal radial fractures. Twenty cases were treated by volar plate using Henry's approach. Six cases were treated with percutaneous K wire fixation. Four cases were treated with external fixator application (Ligamentotaxis). Patients were followed up at one and half, 3 and 6 months after surgery. External fixator was removed after confirming union and advised physiotherapy. For all patients, necessary radiographs were taken at the end of six weeks, three months and six months. Final outcome was evaluated by QUICK DASH evaluation questionnaire.

Quick Dash Evaluation Questionnaire

The Quick DASH score consists of 11 parameters which measure physical function and symptoms in upper limb musculoskeletal disorders.

No	Items	Scoring
1	Opening of jar	1 2 3 4 5
2	Pain intensity	1 2 3 4 5
3	Tingling intensity	1 2 3 4 5
4	Sleeping	1 2 3 4 5
5	Social activities	1 2 3 4 5
6	Washing once back	1 2 3 4 5
7	Forceful recreation	1 2 3 4 5
8	Heavy chores	1 2 3 4 5
9	Carry a bag	1 2 3 4 5
10	Use a knife	1 2 3 4 5
11	Limited in work	1 2 3 4 5

Table 1. Quick Dash Score

Each item has five response options 1 = no difficulty, 2 = mild difficulty, 3 = moderate difficulty, 4 = severe difficulty, 5 = unable to perform.

A summative score was calculated using the formula Dash disability score: [{(Sum of n responses)-1} / n] x 25. The final score ranges between 0 (no disability) and 100 (the greatest possible disability). If two or more items are missing, the score cannot be calculated. Based on the Quick DASH score the functional outcome among patients was graded as.

Excellent outcome	Score between 0 to 25
Good outcome	Score between 25.1 to 50.0
Fair outcome	Score between 50.1 to 75.0
Poor outcome	Score between > 75

Inclusion Criteria

1. Age 15 years to 80 years.
2. All types of Frykman fractures including intra articular fractures (Type I to Type VIII).

Exclusion Criteria

1. Pathological fractures of distal radius.
2. Patients anaesthetically unfit for surgery with co morbid conditions.
3. Poly trauma patients.

RESULTS

In the present study 73.33 % of the patients were males and 26.66 % of the patients were females. The male to female ratio was 2.75 : 1. In the present study the age group ranged from 15 years to 80 years. The study population's mean age was 34.96 years. In the present study 37 % of patients presented with right side distal radius fractures. And 63 % of patients presented with left side distal radius fractures. In the present study 70 % of the patients reported mode of injury as fall on outstretched hand and 30 % reported mode of injury as road traffic accident. Twenty three per cent of patients presented with Frykman's grade IV, 17 % patients presented with grade III & VI, 13 % patients presented with grade I & VIII 6.67 % with grade II & VII. In the present study clinical union was noted among 70 % of the patients at second follow up and 30 % of the patients got clinical union third follow up. Radiological union was noted among 53 % of patients at second follow up and in the remaining 47 % of patients radiological union was seen during third follow up. In the present study during the

third follow up most of the patients had a Quick DASH score of ≤ 25 (77 %). The average score was 18.13. (Table 1)

Score	Number of Cases	Percentage
≤ 25	23	77
26 to 50	7	23
51 to 75	-	-
Total	**30**	**100.00**

Table 2. Quick DASH Score

In the present study the mean radial inclination preoperatively was 7.56 degrees. The mean postoperative radial inclination was 19 degrees. In the present study we report a total of 3 complications, 1 case of joint stiffness, 1 case with superficial infection and 1 case of hardware loosening. With the present study the preoperative mean volar tilt was -11.76 degrees and mean postoperative volar tilt was 8.63 degrees the total correction achieved was 20.39 degrees. In the present study preoperative mean radial length 4.53 mm was observed preoperatively with an immediate postoperative radial length of 9.77 mm, we achieved a mean correction of 5.24 mm during the surgical procedure. Complications occurred in 3 patients (10 %).The present study demonstrated good to excellent results in most of the patients. The mean range of motion achieved in the present study was as follows: palmar flexion of 79 degrees, dorsiflexion of 72.83 degrees, radial deviation of 20.33 degrees, ulnar deviation of 34 degrees, supination of 73.33 degrees, pronation of 71.17 degrees. These results were taken at 6months postoperatively and were compared with the normal side of the patient. In the present study the functional outcome based on Quick DASH score was excellent in 77 % of the patients and while good outcomes were noted among 23 % of patients (Table 2).

Outcome	Number of Cases	Percentage
Excellent	23	77
Good	7	23
Fair	-	-
Total	**30**	**100.00**

Table 3. Final Outcome

DISCUSSION

In the study by Yukichi zenke et al in Japan the mean age was 64.7 years with a standard deviation of ± 17.8 years in conventional group. Their study compared conventional management with MIPO (Minimally Invasive Plate Osteosynthesis) technique for volar plate fixation of distal radius fractures. The mean age in the MIPO group was 62.1 ± 15.6 years. This may be attributed to the average life expectancy of Japanese people when compared to Indian people.[1] However, the mean age observed in the present study was not close but comparable to the studies of Kilic A et al, Chung KC et al and Anakwe E et al who reported an mean age of 45 years, 48.9 years and 48 years respectively.[2,3,4]

Yukichi zenke et al reported high female to male ratio in both conventional and surgical groups akin to osteoporosis in females as the age increases. Similar results have been reported by Tamara D et al with female preponderance in their study.[1,5] In the study by Marco Rizzo. Brain A. Katt. Joshua T. they have shown female preponderance in the group treated with volar locking plate.[9] In a randomised prospective trial K. Egol et al reported equal male to female distribution in both external fixation and volar plating group 50 % and 57 % respectively.[7] Rohit Arora et al in their prospective randomised trial compared non operative treatment with volar locking plate fixation of displaced unstable distal radius fractures in patients aged above 65 years, reported a female preponderance. Study by Kilic A et al reported male gender predominance with a male to female ratio of 1.25:1.[8,2] In the present study left sided fractures were more when compared to right side 63.33 % and 36.67 % respectively. Rohit Arora et al. Tamara D et al reported a predominance of right sided fractures in both Closed Reduction And Percutaneous Pinning (CRPP 95 %) & (ORIF 78 %), this can be attributed to the dominant hand available to protect during the event of injury.[8] The left predominance in the present study suggests non availability of dominant hand as protection during the event of injury.

The common way through which the patients suffered injury in the present study was fall on out stretched hand and the second most common was road traffic accident and majority of them occurred in work place. Akin to male preponderance of the study, this can be attributed to the work group i.e males when compared to females who reside at home. Yukichi Zenke et al, Tamara D et al, K. Egol et al did not report any incidence regarding mode of injury in their studies.[1,5,7]

Yukichi Zenke et al classified the fractures using OTA classification in the order of incidence A2 / A3 / C1 / C2 with values of 19 / 23 / 7 / 17. Tamara D et al reported similar results in their study in both closed and open reduction groups in the same order.[1,5] Present study included predominant intra articular fractures i.e Frykman type IV when compared to the above studies which were purely extra articular fractures of the distal radius.

Yukichi Zenke et al reported 3 % incidence of complications included EPL (Extensor Pollicis Longus) tendon rupture, incomplete paralysis of the superficial branch of median nerve and of cortical screws loosening in conventional ORIF group and 1 % incidence of distal locking screw protrusion in MIPO group.[1] Tamara D et al reported one each case of re-fracture and de Quervain's tenosynovitis along with one case of extensor carpi ulnaris tendinitis both groups did not report any secondary osteoarthritis.[5] Rohit Arora et al reported significantly more complications with operative treatment than non-operative treatment, They used of Fischer exact test which showed a p value of < 0.05. In their study 36 % from the operative treatment group had complications. Five patients in their study had extensor tenosynovitis due to the screw penetration. Four patients developed flexor tendon tenosynovitis which necessitated implant removal; they reported one case of EPL tendon rupture with volar locking plate. A total number of 7 patients in the study including both operative and non-operative group had developed Type-1 CRPS.[8] Marco Rizzo. Brain A. Katt. Joshua T others reported two cases of pin tract infection one case of finger stiffness in their external fixation / pinning group.[9] In the present study we report a total of 3 complications, 1 case of joint stiffness, 1 case with

superficial infection and 1 case of hardware loosening. In the present study the mean radial inclination preoperatively was 7.56 degrees, the mean postoperative radial inclination was 19 degrees. K. Egol et al reported a pre-reduction radial inclination of 14.6 ± 8 degrees and 13.8 ± 7.9 degrees in external fixation and volar plate fixation groups respectively, they reported a postoperative reduction of values of 18.8 ± 6.5 degrees in external fixation group and 17.1 ± 4.7 degrees in plating group postoperatively these results are similar to our study.[7] Yukichi Zenke et al reported a mean radial inclination angle of 26 ± 3.1 degrees and 25.9 ± 3 degrees just after surgery and at the end of study in minimally invasive plate osteo synthesis group and conservative group respectively. Tamara D et al reported an immediate postoperative radial inclination of 22 ± 3 degrees in the open reduction internal fixation group and 21 ± 3 degrees in the closed reduction and percutaneous pinning group. Marco Rizzo. Brain A. Katt. Joshua T others reported a postoperative radial inclination of 23 degrees with volar plate and 21 degrees with external fixator group with no significant p value.[1,5,9](Table 3).

Series	Mean Average Radial Inclination
K. Egol et al	17.1 ± 4.7 degrees
Yukichi Zenke et al	25.9 ± 3 degrees
Tamara D et al	22 ± 3 degrees
Marco Rizzo. Brain A. Katt. Joshua T others	23 degrees
Present study	19.00 degrees

Table 4. Radial Inclination Compared with Other Series

Series	Mean Volar Tilt (Deg)
K.Egol et al	-14.5 ± 22.1 degrees
Yukichi Zenke et al	10.7 ± 5.2 degrees
Tamara D et al	2 ± 4 degrees
Marco Rizzo. Brain A.et al	11 degrees
Present study	8.63 degrees

Table 5. Volar Tilt Compared with Other Series

With the present study the preoperative mean volar tilt was -11.76 degrees and mean postoperative volar tilt was 8.63 degrees the total correction achieved was 20.39 degrees, the higher degree of correction achieved was due to the fact that the dorsal tilt was expressed in negative value and hence the correction achieved was greater than the normal range (0 – 11 degrees).

K. Egol et al reported preoperative mean volar tilt of -15.8 ± 19.1 degrees with external fixation group and - 14.5 ± 22.1 degrees in volar plating group these results closely approximate our results. Yukichi Zenke et al reported the mean volar tilt angle 13 ± 4.4 degrees immediate postoperative in the conventional group and 10.7 ± 5.2 degrees in the minimally invasive plate osteo synthesis group indicating that their cases angulated minimally volarly postoperative due to relative over correction.[7,1] Tamara D et al reported an immediate postoperative tilt of 2 ± 4 degrees in open reduction internal fixation group and 5 ± 5 degrees in closed reduction and percutaneous pinning group this indicates the under correction they achieved in volar tilt with a p value of 0.09 which is not significant statistically. Marco Rizzo, Brain A. Katt, Joshua T others showed a postoperative volar tilt of 11 degrees in volar plate group and 3 degrees in external fixation group with a significant p value of 0.041[5,9] (Table 4).

K. Egol et al reported a mean radial length of 7 ± 4.2 mm pre reduction value in external fixation group, 6.9 ± 4.2 mm in volar plating group preoperatively they achieved a radial length of 9.5 ± 3.5 mm in external fixation group and 9.3 ± 3 mm in volar plating group they showed no statistical significance in achieving radial length.[7] Yukichi Zenke et al described ulnar variance instead of radial length for both preoperative and postoperatively for both conventional group and minimally invasive plate osteo synthesis group. Tamara D et al reported an immediate postoperative reduction of radial height to 11 ± 2 mm in open reduction and internal fixation group as well as closed reduction percutaneous pinning group and their results did not change through out the follow up. Marco Rizzo. Brain A. Katt. Joshua T others reported an immediate postoperative radial height of 11 mm in volar plate group and 10 mm in external fixation / pinning group.[1,5,9]

In the present study preoperative mean radial length 4.53 mm was observed preoperatively with an immediate postoperative radial length of 9.77 mm, we achieved a mean correction of 5.24 mm during the surgical procedure.

The present study demonstrated good and excellent results in most of patients. Minegishi H et al in 2011 evaluated the functional and radiological outcome of treatment of unstable distal radius fractures with the volar locking plate among 15 patients and reported 5 patients with excellent outcome, 7 with good outcome, and three with fair outcome. They used Cooney's clinical scoring chart to evaluate the results.[10]

K. Egol et al showed a mean DASH score of 17.2 ± 33.7 in external fixator group and 13 ± 30.9 in volar plating group at 12 months, but their functional DASH score at 6months was 32.6 ± 23.8 in external fixator group 25.0 ± 21.7 in volar plating group at 3months interval their DASH scores was 25.4 ± 21.1 in external fixator group and 19.5 ± 20.1 in volar plating they did not compare DASH scores at 6 weeks interval.[7] Yukichi Zenke et alevaluated DASH scores sequentially weekly upto 12 weeks and at final examination they reported 5.6 ± 6.3 in the conventional group and 4.2 ± 6.8 in the mipo group at 12 weeks.[1] Tamara D et al recorded a DASH score 27 ± 17 at 6weeks in orif group and 53 ± 28 in crpp group at 6weeks they reported a DASH score 11 ± 13 in orif group and 26 ± 23 in crpp group at 12 weeks with significant p value of 0.01 they recorded another DASH score at 1year in which the orif group fared with 4 ± 8 score and crpp fared 9 ± 18 with no significant p value.[5] Marco Rizzo. Brain A. Katt. Joshua T reported a DASH score of 9 in volar plate group and 23 in external fixator / pinning group at the end of the study of 1 year with a significant p value of 0.01, they used physiotherapy sessions of 1 to 10 in volar plating groups and 4 to 20 in external fixator group.[9]

Series	Score
K.Egol et al	25.0 ± 21.7
Yukichi Zenke et al	5.6 ± 6.3
Tamara D et al	11 ± 13
Marco Rizzo. Brain A. Katt.Joshua T	9
Present study	18.13

Table 6. Quick Dash Score Compared with Other Series

In present study Quick DASH score at 6 months follow up was 18.13 (Table 5). The mean range of motion achieved

in the present study was as follows palmar flexion of 79 degrees, dorsiflexion of 72.83 degrees, radial deviation of 20.33 degrees, ulnar deviation of 34 degrees, supination of 73.33 degrees, pronation of 71.17 degrees. These results were taken at 6months postoperatively and were compared with the normal side of the patient. K. Egol et al reported a palmar flexion of 80 ± 17.8 degrees, extension of 81 ± 12.1 degrees, radial deviation of 73 ± 8.1 degrees, ulnar deviation of 70 ± 5.8 degrees supination of 85 ± 12.8 degrees and pronation of 95 ± 14.6 degrees at 6 months interval they required 34.2 ± 16.7 physiotherapy sessions to attain range of motion described at 6months.[7] We used only one physiotherapy session for 2 weeks and advised patients practice at home. Yukichi Zenke et al at the end of their study reported only flexion and extension and pronation and supination in both conventional groups 86.0 ± 6.7 degrees, 68.3 ± 5.6 degrees, 88.8 ± 3.4 degrees, 88.2 ± 5.7 degrees respectively and in mipo groups 86.5 ± 6.7 degrees, 67.2 ± 6.7 degrees, 88.9 ± 3.2 degrees, 88.6 ± 4.3 degrees respectively. Tamara D et al reported the range of motion at 12 weeks as flexion 58 ± 13 degrees, extension 58 ± 14 degrees, radial deviation 22 ± 9 degrees, ulnar deviation 35 ± 6 degrees, supination 84 ± 13 degrees & pronation 85 ± 11 degrees and showed a significant p value these values approximate our values at 6months duration post operatively. Marco Rizzo. Brain A. Katt. Joshua T others flexion of 64^0, extension of 69^0, radial deviation of 23^0, ulnar deviation of 34^0, pronation of 78^0 and supination of 76^0 at their final follow up these values approximate our values at 6 months duration post operatively.[1,5,9]

Chaudhry et al. in their meta-analysis concluded that volar locking plates showed improved DASH scores at 3 months and at 12 months follow up when compared with K-wire fixation for displaced distal radius fractures in adults.[11] Mert Kumbaraci et al in their article titled "Retrospective comparison of external fixation versus volar locking plate in the treatment of unstable intra-articular distal radius fractures" concluded that both volar locking plating and external fixation fared equally regarding functional outcome.[12] Tulgar Toros et al. in their article titled "Complications of distal radius locking plates" concluded that these plates produced better stability and resulted in early mobility but they are not devoid of complications like screw prominence, extensor pollicis longus tendon rupture etc.[13]

Matthew L Costa et al in a randomised controlled trial concluded against the existing literature, and against the popular use of locking plate fixation. They found no difference in functional outcome between locking plate fixation and K wire fixation. In fact, they commented that K wire fixation was both economical and less time consuming.[14] This stresses the importance of anatomical reduction as well as maintaining the reduction till fracture union were most important in achieving a better functional outcome.

CONCLUSIONS

Functional outcome correlated positively with the degree of radial length, volar tilt, and radial inclination achieved when compared to the normal side. The method of internal fixation with volar locking plate appears to be favoured by many akin to its ability to sustain the reduction. Comminuted intra articular fractures fared less well with more number of complications. However, fracture union time seems to be unaffected by the method of fixation.

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