Comparison of volar locking plate and external fixation with K wire augmentation in unstable distal radius fractures

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ABSTRACT

Distal radius fractures are one of the most common injuries and this incidence is likely to increase as the aging population increases. The type of operation and implant is a matter of discussion and randomized trials and meta analyses have failed to recommend the preferred implant. Internal fixation with volar locking plate and external fixation with supplementation with K wire have been successfully employed in these fractures. Forty eight patients unstable distal radius fractures treated from 2008 to 2014 with either a volar locking plate or an external fixation with K wire supplementation were analyzed. Radiographic measurements like dorsal angle in degrees, radial inclination in degrees, ulnar variance in millimeters and radial length in millimeters were taken. Functional evaluation was assessed with the clinical rating as devised by Cooney(modified from Green and O'Brien). These patients were treated with volar locking plate (n- 26) and external fixation with K wire (n-22). Patients were treated with a three or four holes 3.5mm volar locking plate and wrist spanning external fixator with two K wire supplementation. Sixteen A3, fourteen C1, eleven C2, and seven C3 fractures were treated. By six weeks, the mean functional outcome score in the volar plate group was significantly better than that in the external fixation group ($p = 0.037$). At three months, the mean score in the volar plate group was significantly better than that in the external fixation group ($p = 0.028$). However, by six months, the score in the volar plate group was not significantly different from that in the external fixation group ($p = 0.26$). At one year, the mean score in the volar plate was not significantly different from the mean score in the external fixation group ($p = 0.056$). At one year, the degree of radial inclination and the radial length in the patients with a volar locking plate were significantly greater than those in both the patients treated with external fixation ($p = 0.007$ and $p = 0.002$, respectively). Although volar locking plate has certain advantages over the external fixation in the earlier post operative period, this decreases as time passes. Both fixation techniques seem to apply sufficient stabilization to restore and retain anatomy after fracture of distal part of the radius and should be individually chosen accordingly.

Keywords: distal radius fractures, volar locking plate, external fixation

INTRODUCTION

Distal radius fractures are one of the most common injuries seen and has been reported as 27 per in 10000 inhabitants.[1] The incidence is likely to increase as the aging population increases. The type of operation and the choice of implant is still, however, a matter of discussion; a Cochran report states that "randomized trials do not provide robust evidence for most of the decisions necessary in the management of these fractures" .[2] Hence, an individual case approach was deemed necessary and surgeons should be familiar with the many treatment modalities. The ideal surgical method should maintain the anatomical position and ensure early mobilization. Anatomical reduction with stable fixation is the preferable treatment of unstable distal radius fractures.

Various forms of treatment from combination of external and internal fixation and percutaneous K wire fixation have been reported to have good clinical and radiological outcomes. [3] Some studies have reported that patients who underwent open reduction with locking plate had an earlier return to work than patients treated with external fixation in complex distal radius fractures. [4] Others have suggested that better functional results can be expected in the early postoperative period in association with open reduction and internal fixation, and this form of treatment should be considered for patients requiring a faster return to function after the injury. [5] External fixation (EF) alone for communited distal radius fractures are associated with loss of reduction hence addition of K-wires in the fixation has been suggested to better maintain the reduction. [6] In a randomized trial the authors have shown the function to be superior in indirect reduction and percutaneous pinning than in open reduction and internal fixation (ORIF). [7] Some studies have shown that there is no significant difference in the outcome of intra-articular distal radius fractures treated with either EF or ORIF. [8] While others have also shown that internal fixation provides better grip strength and a better range of motion in 1 year, and also tends to have less malunions than external fixation. However, no difference could be found regarding subjective outcome. [9] Another study has shown that distal radius fractures treated with internal fixation had better wrist flexion, wrist extension, pronation and supination compared to the external fixation. [10]

Earlier meta-analysis had reported that there is no evidence to support the use of internal fixation over external fixation for unstable distal radius fractures and concluded that comparative trials using appropriately sensitive and validated outcome measurements are needed to guide treatment decisions. [11] However, in a recent meta-analysis Cui et al reported that the final results are significant and there is some evidence supporting the use of open reduction and internal fixation. [12] In another recent meta-analysis they concluded that ORIF with plate fixation provides lower DASH scores, better restoration of radial length and reduced infection rates as compared to external fixation for treatment of distal radius fractures.[13]

Hence, the purpose of our study was to determine the functional outcome in patients with unstable intra-articular distal radius fractures treated with volar locking plate versus external fixation with K-wire supplementation in our set up.

MATERIAL AND METHODS

All unstable distal radius fractures reporting to Kathmandu Medical College Teaching Hospital from 2008 till 2012 were prospectively documented and treated and those treated with either a volar locking plate or an external fixation with K-wire supplementation were analyzed. Patients who did not meet the criteria were counseled for operative intervention. [14]

Guidelines for Acceptable Reduction of Distal Radius Fractures14

1. Radial shortening <5 mm at the DRUJ compared with the contralateral side
2. Radial inclination on posteroanterior radiographs >15°
3. Sagittal tilt on the lateral projection between 15° dorsal tilt and 20° volar tilt
4. Intra-articular step-off or gap <2 mm of the radiocarpal joint
5. Articular incongruity <2 mm of the sigmoid notch of the distal radius

A total of 48 patients could be followed up for one year post operatively. Patients with external fixator in whom no K-wire supplementation was done were excluded. Patients who had to undergo open reduction to stabilize the fracture in the external fixation group were excluded. All AO/OTA classification type B fractures were also excluded.

Surgical Treatment

All surgeries were performed either in brachial plexus block or general anesthesia under tourniquet control.

External fixation and K wire supplementation technique

The fracture was reduced with traction and direct manipulation and k-wires were inserted to maintain the reduction. Two K-wires 1.8mm were inserted percutaneously, first wire was inserted at the radial styloid between the first and second dorsal wrist extensor compartment and the second wire between fourth and fifth dorsal wrist extensor compartment.

Fig. 1 A :43 year old female with unstable distal radius fracture treated with External fixation and K wire (Pre operative AP and Lat radiographs)

Both K-wires were bent and cut and left superficially to the skin. Additionally, one 1.8mm k-wires are used to secure the reduction if deemed necessary. After k-wire stabilization, the external fixator was applied. Two pins are placed into the index finger metacarpal through a dorsal–radial incision. The apparatus was measured out to length and an incision is placed over the radial–dorsal aspect of the radius. Two radius pins are placed between the extensor carpi radialis brevis and longus. The device is then secured and the traction is removed. Final reduction was checked under C-arm for confirmation.

Fig. 1 B Post operative radiograph treated with External fixation and K wire

Postoperatively, the fixator remains in place for approximately 6 weeks. Finger ROM is encouraged immediately. At 2 weeks after surgery, the sutures were removed. Wrist ROM was started after external fixator removal. Strengthening was initiated as ROM improved and normalizing of symptoms.

The technique and postoperative protocol for volar locking plate was as descried earlier in our study. [15]

Fig. 2 A - A 53 year old male with unstable distal radius fracture treated with volar locking plate (Pre operative Lat and AP radiographs)

The following radiographic measurements like dorsal angle in degrees, radial inclination in degrees, ulnar variance in millimeters and radial length in millimeters were taken.

Patient Assessment

Patients were followed up at 6 weeks, 3 months, 6 months and one year after surgery and radiographs were taken. Functional evaluation was assessed with the clinical rating as devised by Cooney (modified from Green an O'Brien) (Table 1) as follows: pain, functional status, range of motion, and grip strength measured as percentage of normal (range, 0-25 points) Points were added for the four categories and a final rating were obtained as follows: excellent, 90-100 points, good, 80-90 points; fair, 65-80 points, and poor, less than 65 points [16]

Fig. 2 B Post operative radiographs with volar locking plate

RESULTS

Forty –eight distal radius fractures treated with either external fixation and K wire or a volar locking plate with at least one year follow up were evaluated. These patients with unstable distal fractures were treated with volar locking plate (n- 26) and external fixation with K wire (n-22). Patients were treated with a three or four holes 3.5mm volar locking plate and wrist spanning external fixator with two K wire supplementation. The demographics of the two groups are shown in Table 2.

Table 1. Clinical Scoring Chart: Cooney WP (modified from Green and O'Brien)

Pain (25 points)	Functional status (25 points)	Range of motion (25 points) Percentage of normal	Grip Strength (25 points) % if normal
25 no pain	25 Return to regular employment	25 - 100%	25 - 100%
20 mild occasional	20 restricted employment	– 75%-100%	– 75%-100%
15 moderate tolerable	15 able to work, unemployment	10 – 50%-75%	10 – 50%-75%
0 severe to intolerable	0 unable to work because of pain	5 – 25% - 50%	5 – 25% - 50%
		0 – 0% - 25%	0 – 0% - 25%

Table 2. Demographic data between groups

	Ex-fix and pinning group	Volar locking plate group
Number of patients	22	26
Gender (M/F ratio)	9:13	11:15
Average age (years)	53.22 (34-73)	53.65 (38-70)
Average follow up	(14-48)	(12-42 weeks)

Sixteen A3, fourteen C1, eleven C2, and seven C3 fractures were treated.

By six weeks, the mean functional outcome score in the volar plate group was significantly better than that in the external fixation group ($p = 0.037$). At three months, the mean score in the volar plate group was significantly better than that in the external fixation group ($p = 0.028$). However, by six months, the score in the volar plate group was not significantly different from that in the external fixation group ($p = 0.26$). At one year, the mean score in the volar plate was not significantly different from the mean score in the external fixation group ($p = 0.056$).

The percentage of the contra lateral grip at six months by the patients treated with volar locking was significantly higher than that recovered by those treated with the external fixation ($p = 0.042$). No other significant differences in grip strength were found among the groups at any other follow-up period, and both groups demonstrated significant improvement from six months to one year postoperatively ($p = 0.05$).

The range-of-motion improved significantly from six weeks to one year in both the groups ($p < 0.05$). At the final evaluation, wrist flexion-extension averaged 110 ± 20 (84% ± 15% of the value on the contra lateral side), forearm pronation-supination averaged 145 ± 21 (92% ± 10% of the value on the opposite side), and wrist radio-ulnar deviation averaged 46 ± 7 (98% ± 21% of the value on the opposite side).

The pain scores on visual analog scale did not reveal any significant differences among the groups during any follow up period ($p > 0.05$). (Table 3)

An analysis of radiographs at six weeks showed that the volar locking plate maintained significantly greater radial inclination than did the volar plate ($p = 0.003$) and significantly greater radial length than did external fixation ($p = 0.038$) (Table 4).

Table 3. Pain on visual analogue scale (10 point scale) Mean and standard deviation

Group	Ex-fix and K wire	Volar locking plate
Baseline	2.8 ± 2.0	3.6 ± 2.1
6 weeks	1.9 ± 1.1	2.3 ± 1.4
3 months	1.9 ± 0.9	1.7 ± 1.0
6 months	2.2 ± 1.3	1.8 ± 1.0
12 months	1.8 ± 1.2	1.8 ± 1.8

Table 4 Radiographic measurements

Preoperative	Ex-fix and K wire group	Volar locking plate group
Dorsal angulation (deg)	28.9 ± 15.3	26.7 ± 19.5
Radial inclination (deg)	16.5 ± 9.1	15.0 ± 10.4
Ulnar variance (mm)	2.7 ± 3.0	0.2 ± 4.4
Radial length (mm)	8.1 ± 3.8	8.0 ± 5.2
6 weeks		
Dorsal angulation (deg)	0.8± 11.6	0.4 ± 9.4
Radial inclination (deg)	23.0 ± 6.9	19.4 ± 4.3
Ulnar variance (mm)	-0.7±2.1	-1.1±2.5
Radial length (mm)	13.0 ± 3.5	11.4 ± 2.1
12 months		
Dorsal angulation (deg)	4.0 ± 12.0	2.1 ± 13.4
Radial inclination (deg)	24.5 ± 5.2	20.4 ± 3.4
Ulnar variance (mm)	-0.2 ± 2.3	0.0 ± 4.3
Radial length (mm)	12.5 ± 3.5	10.8 ± 2.1

Radiological study at six weeks showed that the volar locking plate maintained significantly greater radial length than did external fixation ($p = 0.038$). At one year, the degree of radial inclination and the radial length in the patients with a volar locking plate were significantly greater than those in both the patients treated with external fixation ($p = 0.007$ and $p = 0.002$, respectively). The intra-articular fractures step did not reveal any significant differences among the groups ($p > 0.05$), but there was a slight inclination toward a higher proportion of patients with a minor gap deformity in the external fixation group ($p = 0.09$).

The functional outcomes of the patients with both internal and external fixation were follows. Volar locking plate:

Excellent 17 , Good 6, Fair 2 and Poor 1. The patient

with the poor outcome did not follow our instruction and removed the posterior slab after 5 days and started moving her upper limb for household work. We revised with plate removal and external fixation and K wire supplementation after two weeks. At one year follow up she still had mild deformity and had to take medication for pain relief occasionally.

External fixation group:

Excellent 12, Good 6, Fair 3 and Poor 1

There were very few complications in both groups of patients. There were no wound complications in the internal fixation group with one patient complaining of mild tingling over the hand which eventually subsided with neuropathic pain medication. Two patient developed superficial pin tract infection which resolved with oral antibiotics. There was one patient with RSD in the external fixation group and had to have two episodes of stellate ganglion blockage. The symptoms later subsided and had a fair outcome.

DISCUSSION

The treatment goals when treating distal radius fractures are to restore the articular congruity, achieve radial alignment and height, provide mobility for maintenance of finger-wrist, and ensuring stability of the fracture to protect alignment- joint surface congruency until recovery. Using the same mode of treatment in different fractures types of the distal radius may not be possible as the anatomical and mechanical forces are different. [17, 18]

External fixation is used to maintain axial length while reduction is attained by manipulation of fracture fragments with supplemental Kirschner wires and ligamentotaxis but cannot directly reduce intra-articular fracture fragments in unstable fracture patterns. Traction alone in external fixation cannot correct palmar angulation as ligamentotaxis primarily functions through strong palmar links. [19]

Open reduction and internal fixation has the advantage of directly manipulating the fragments and reduce them. Several studies have shown that volar locking plate has been a good option for treating unstable distal radius fractures with minimum complications. Comparing with external fixation, volar locking plate technique has a distinct advantage in the earlier rehabilitation period in treating these fractures. [20]

We found that, compared with external fixation and K wire the use of a locked volar plate led to a more rapid improvement in subjective function. This advantage over external fixation was seen at the six week time point, but may be due to delay in initiating therapy when a spanning external fixator is in place. By three months, the patients with a volar plate had a higher level of subjective function than the patients treated with external fixation. By six months, all two groups demonstrated excellent functional scores, and at one year, the patients in the volar plate group had better subjective function but not statistically significant. Thus, the patients who had been treated with a volar plate had the distinct advantage of achieving normal subjective function three months earlier than the patients who had been managed with either external fixation.

The increased in the grip strength found in our study compares with the meta analysis done be Xie et al. [21] They also found that grip strength was better in the internal fixation with volar locking group and recommended this form of fixation should be considered for patients requiring a faster return to function after injury.

Marcheix et al. randomized 103 patients over the age of 50 years with unstable extra- and intra-articular fractures (including comminuted C2 and C3 fractures) to volar locked plating or "mixed pinning". At 3 and 6 months, the plated patients had better objective functional results and reported better DASH scores, in accordance with our findings. [22]

We agree with Wilcke et al that the more rapid recovery of patient-perceived and objective wrist function in patients treated with volar locked plating, compared to external fixation, is due to the earlier active wrist mobilization postoperatively that is allowed by the volar locked plating technique. [20]

We also found that radiologically, the volar plating was associated with better correction of volar angulation and protection of ulnar variance. This may be explained by the fact that distraction primarily occurs via volar structures and that volar locking plate provides a better support to the fracture. Traction alone in external fixation cannot correct volar angulation because ligamentotax is primarily functions through strong volar links and losses in volar angulation may be seen during follow-up. The superior mobility achieved with the volar locking plate may be because these patients can start wrist movements earlier owing to stable fixation. All external fixators used in our study extended beyond the joint and was removed on the average of six weeks. Thus, mobility of the wrist joint was not allowed until the fixator was removed. This may explain mobility losses in the external fixation group.

We agree with Gereli et al that although volar locking plates have their advantages, not all fractures especially very distal comminuted fractures that do not allow screw insertion, K-wire with external fixation may give successful results. [23]

The volar fixed-angle plate maintains reduction through the fixed subchondral supports, preventing the metaphyseal bone from collapsing and the subsequent loss of volar tilt.

Although it was not statistically significant, there seemed to be a trend for patients treated by internal fixation to resume their usual activities quicker than those treated with EF, suggesting that ORIF is more adapted to active, young patients, whilst EF may be convenient for less active,

elderly patients. These results suggest that the patient's functional needs should be considered before making the choice for the more appropriate surgical technique.

The fixed-angle nature of volar locking plates achieves adequate stability for unstable distal radius fractures and allows early wrist mobilization, leading to improved strength. [24]

It has been reported that functional results are considered to be stabilized 6 months after operation, even though there might be some progress in the range of motion and grip strength after this period and we also observed similar outcomes. [25,26]

Although volar locking plate has certain advantages over the external fixation in the earlier post operative period, this decreases as time passes. Both fixation techniques seem to apply sufficient stabilization to restore and retain anatomy after fracture of distal part of the radius and should be individually chosen accordingly. [27]

The method of fixation should be chosen according to the activity of the patient and the fracture morphology. Volar locking plate has the advantage of mobilizing the limb earlier and return to work while external fixation can be equally effective in communited unstable fractures where the fracture is too distal for plate application and screw purchase.

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