

Clinico- Radiological and functional outcome after surgical fixation of intraarticular fractures of distal end of radius by external fixator verses locked volar plate: A prospective randomised study

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Abstract : Background: Intra- articular fractures of the distal radius represent high energy, complex, unstable injuries and the optimal method of treatment remains controversial.

Study Design & Settings: Observational Randomized uncontrolled Study at a tertiary care hospital from September 2010 to August 2012.

Material & Methods: Fifteen patients underwent open reduction and palmar locking plate fixation, and 15 patients underwent closed reduction and K-wire augmented external fixation on random basis. For functional and radiological assessments, Demerit score were used and grip strength was measured using a Dynamometer. Subjective functional assessment was made using the DASH scale. The follow-up period was at least 6 months.

Statistics: Observational descriptive statistics, Student's unpaired 't' test and Chi-square test.

Results: The radiological parameters at three and six months were better in patients treated with plate group. Patients in the plate group had better functional outcome score (DASH). The findings were statistically significant at three months period but did not show any significance at six months period. Functionally and radiologically (DEMERIT Score) plate group had better score. The findings were statistically significant in three months period, but did not show any significance at six months period. Patients in the plate group showed better grip strength. In patients whose right hand was involved the findings were statistically significant at three months but at six months there was no statistical significance.

Conclusion: Treatment with open reduction and internal fixation for intra articular fractures of distal end of radius provides good radiological results. However, objective and subjective functional assessment showed no significant superiority between external fixation and volar plate fixation at 6 months follow-up.

Keywords - DASH & DEMERIT Score, External fixator, Fracture distal radius, Functional assessment, Volar plate.

I. Introduction:

Treatment of displaced fractures of the distal end of the radius has changed over the course of time. In the past, closed reduction with immobilization in a plaster cast was considered the treatment of choice. Dr. Abraham Colles, in reference to fractures of the distal aspect of the radius, stated: "One consolation only remains, that the limb will at some remote period again enjoy perfect freedom in all its motions, and be completely exempt from pain; the deformity, however, will remain undiminished throughout life" [1].

Many fractures of the distal aspect of the radius are in fact relatively uncomplicated and are effectively treated with closed reduction and immobilization in a cast. However, fractures that are either unstable and/or involve the articular surfaces can jeopardize the integrity of the articular congruence and/or the kinematics of these articulations. Most orthopaedic surgeons today would agree that a patient with a malunited fracture of the distal end of the radius who "enjoy[s] perfect freedom in all . . . motions, and [is] exempt from pain," is the exception, not the rule. The goal of the treating physician should then be to restore the functional anatomy by a method that does not compromise hand function. The fracture pattern, the degree of displacement, the stability of the fracture, and the age and physical demands of the patient determine the best treatment option [2].

In theory plating of intra articular fractures gives early mobility and the patient is free from cast. The long term results are not very different when compared with minimal fixation group. The purpose of this study was to find the difference between radiological and functional outcome of patients having intra articular fractures of distal radius treated by two different methods a) Minimal fixation with external fixator and K-wire and b) Internal fixation with volar plate and to establish any significant difference between the two groups.

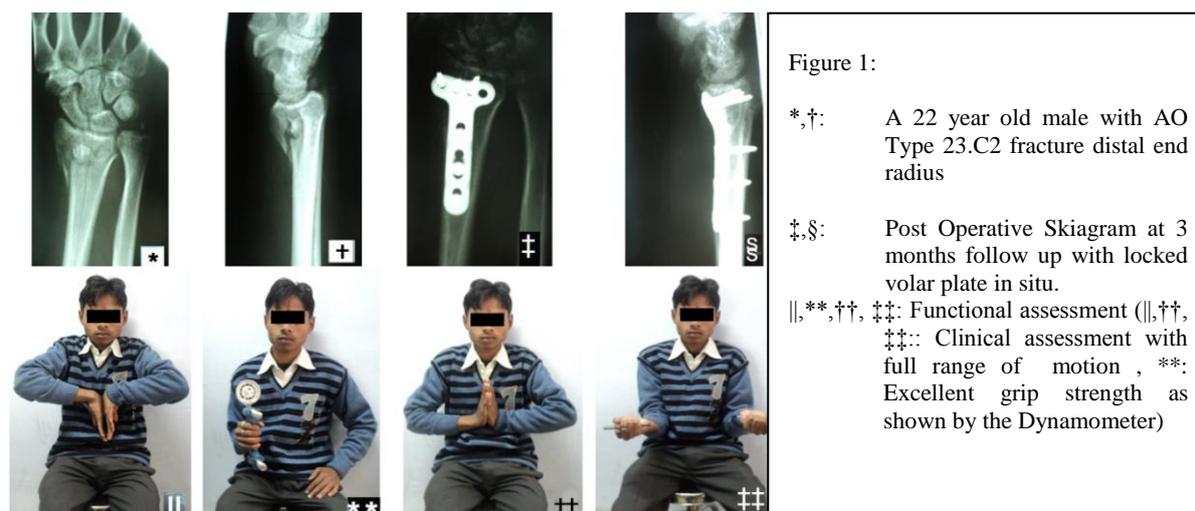
II. Material & Methods:

A Prospective randomised study of 30 patients was made, who were treated with palmar locking plate or K-wire augmented external fixation for intra-articular distal radius fractures at the Department of Orthopaedic Surgery, at our tertiary care centre over a period from September 2010 to August 2012.

Patients included in the study were adults (Age 20 – 60), patient with intra articular fractures of distal end of radius (AO Type B/C), all closed and Grade I (Gustillo and Anderson) compound fractures and presenting within 72 hours of injury. Patients with Grade II and III open fracture distal radius, pathological fractures, rheumatoid arthritis, unresolved contracture of forearm and neurovascular injuries were excluded. Based on the patient's entry into the study registry, even numbered cases were treated with plate fixation and odd numbered cases were treated with external fixator. Fifteen patients were treated with open reduction and fixed-angle palmar locking plate and 15 patients were treated with closed reduction under fluoroscopy, distraction with the external fixator and K-wire fixation.

The fractures were assessed preoperatively by wrist radiographs and were classified according to the AO/ASIF classification system. Four patients (13.33%) had 23.B2 type of fracture, 10 patients (33.33%) had 23.B3 type of fracture, 5 patients (16.66%) had 23.C2 type of fracture and 11 patients (36.66%) had 23.C3 type of fracture.

During surgery, a palmar Henry incision was used for the palmar approach. In the external fixation group, distraction with the Orthofix type external fixator was performed following closed reduction under fluoroscopy. For additional stability, the fragments were reduced and fixed with 1.5 and 1.7 mm K-wires. The ends of the wires were left in the skin. Following surgery, a wrist slab was used in the palmar locking plate group. Active finger exercises were started on the day after surgery. The plaster slab was removed at 12th day when the suture line was healthy and the sutures were removed. Rehabilitation was started with active and passive exercises. The patients were allowed to carry load and do heavy work after completion of three months. In the external fixation group, finger exercises were started the day after surgery. After clinical and radiographic evaluation at 2 and 4 weeks, the K-wires used for support were pulled out between week 4 and week 6. When radiographic findings of solid union were observed, the external fixator was removed under sedation after an average of 6- 8 weeks, and rehabilitation with active and passive exercises were started with the support of a brace. The patients were allowed to carry load and do heavy work after three months. Immediate post-operative check X-rays was taken in both AP and lateral views. Radiographic Parameters that were taken are Radial length, Palmer tilt and Radial angle. Patient was followed up at 3 weeks, 6weeks, 3 months and at 6months till patient was rehabilitated (Fig. 1, 2). On each visit, clinical, radiological and functional outcome of patient was assessed with the help of Demerit score [3] and DASH score (The Disabilities of the Arm, Shoulder and Hand score) [4] and Grip strength with the help of a Dynamometer (measured in kilogram). Data was entered and analysed on Microsoft Excel and SPSS version 19. Data was compared using Student's Unpaired 't' test and 'Chi- Square test'. Quantitative data was expressed in terms of mean ± SD.





III. Results:

It was observed that the immediate post operative radiological parameters were better in patients treated with plate group than in the external fixator group and was statistically significant with respect to radial angle (p value= 0.011) and the radial height (p value= 0.0002). The radiological parameters at three months were better in patients treated with plate group than in the external fixator group and was statistically significant with respect to radial angle (p value= 0.003), radial height (p value= 0.0001) and palmer tilt (p value =0.005). The same findings were seen at six months (Table 1).

Table 1: Radiological evaluation: Preoperative, immediate and 3 months post operative (mean± SD) (n=30) (Ext. Fix.- External fixation)

		Palmar tilt (degree)	Radial angle (degree)	Radial height (mm)
Pre-op	Ext. Fix.	5.06±4.57	11.2±8.23	4.73±6.27
	Plate	7.06±6.37	14.22±3.66	3.66±3.41
Post-op (immediate)	Ext. Fix.	9.13±2.13	18±2.90	10.13±1.76
	Plate	10.2±1.52	20.13±0.91	13±1.92
	<i>P value</i>	<i>0.124</i>	<i>0.011</i>	<i>0.0002</i>
Post-op (3 months)	Ext. Fix.	7.26±3.49	16.6±3.83	7.93±3.59
	Plate	10.2±1.52	19.9±0.96	12.9±1.98
	<i>P value</i>	<i>0.005</i>	<i>0.003</i>	<i>0.0001</i>

DASH questionnaire is a validated self-reported thirty item metric of the upper extremity function based on 100- point scale, with 0 points indicating no disability and 100 point indicating maximum disability (Table 2). In the plate group the worst DASH score at three months was seen in a case which was noncompliant to post operative physiotherapy protocol but showed marked decrease in the score after vigorous physiotherapy at end of six months. In the external fixator group the worst DASH score which was seen in one of the patients at three months had collapse of the fracture fragment This patient also had improvements in DASH score at six months, with physiotherapy. The above findings showed that the patients in the plate group had better functional outcome score than in the fixator group. The findings were statistically significant at three months period (p value = 0.045), but did not show any significance at six months period (p value = 0.126).

Demerit system consists of subjective evaluation, objective evaluation and complications assessment. The evaluations were graded as excellent, good, fair and poor according to the demerit score and recorded as per Table 3. The above findings say that functionally and radiologically plate group had better score. The findings were statistically significant in three months period (p value= 0.009), but did not show any significance at six months period (p value=0.076).

Table 2: DASH Score at 3 and 6 months. (mean ± SD) (n=30)

DASH score	Plate	External fixation	P value
3 months	33.13±20.30	50.89±25.93	0.045
6 months	8.79±6.46	13.79±10.46	0.126

Table 3: Demerit score at 3 and 6 months (n=30)

Demerit score	3 months		6 months	
	Plate	External fixation	Plate	External fixation
Excellent (0-3)	4	0	9	5
Good (4-9)	9	5	6	6
Fair (10-15)	2	5	0	4
Poor (16-26)	0	5	0	0
P value	0.009		0.076	

Grip strength (Dominant hand):-The mean grip strength at three months in external fixator group was 12.8±5.82 and 21±7.91 in the plate group. The mean grip strength at six months in external fixator group was 18±5.99 and 23±5.52 in the plate group.

Grip strength (Non-dominant hand):-The mean grip strength at three months in external fixator group was 13.2±3.03 and 15.42±2.22 in the plate group. The mean grip strength at six months in external fixator group was 17.2±1.09 and 19.14±1.95 in the plate group. The above findings show that the patients in the plate group showed better grip strength than the external fixator group. The findings were statistically significant at three months (p value= 0.022) in patients whose dominant hand was involved but at six months there was no statistical significance.

In the plate group two patients (6.66%) had screw impingement and three patients (10%) had developed stiffness at final follow up. In the external fixator group four patients had stiffness (13.33%), three (10%) had collapse of the fracture segment and two patients (6.66%) developed features of reflex sympathetic dystrophy (Figure.3). None of the cases had any non union.

IV. Discussion

The treatment of distal radius fractures has undergone changes owing to the advances in technology. Improved imaging methods providing better understanding of fractures and elucidation of the effects of injury type on fracture formation and factors leading to instability have given way to new fixing methods and materials appropriate for the fracture, resulting in today's treatment options in distal radius fractures.

The wrist joint is composed of three separate joints: the radio-carpal, the ulno-carpal and the distal radio-ulnar joint. A malalignment or dysfunction of one of these joints inevitably leads to a dysfunction of the wrist as a whole. Beside the bony cartilaginous anatomy, also the radio-carpal, ulno-carpal and intercarpal ligaments and the triangular fibro cartilaginous complex seem to be of utmost importance. Dysfunction of these structures can lead to bad outcome after a fracture of the distal radius [5]. The distal aspect of the radius functions as an articular foundation of the wrist joint. Integrity of the osseous, articular, and ligamentous structures is needed to maintain motion and transmit load [2].

Displaced fractures especially the unstable ones, need stable fixation. Lafontaine, Hardy and Delince identified the following predictors of instability :- Patient over 60 years, an intra articular fracture, dorsal comminution, dorsal angulations more than 20° and associated ulnar fracture [6].

Dorsal angulations in distal radial fractures are common and there is tendency towards secondary displacement after conservative management. Distal radius is important in the kinematics of radiocarpal and radioulnar joints. Hence, open reduction of the articular surface, stable reduction, restoration of the radial length, volar angulation and radial inclination are the prerequisite for good clinical outcome. All this reduces the incidence of post-traumatic osteo-arthritis and allow early functional rehabilitation [7].



Fig 3: Common Complications following External Fixation of fracture of distal end radius

- * , †: Pre operative Skiagram (AO Type : 23.C3)
- ‡ , §: 3 months follow up showing features of reflex sympathetic dystrophy.
(note: External fixator was removed at 6 weeks.)
- || , **: 45 year old male with comminuted AO Type: 23.C3 fracture distal radius.
- †† , ‡‡: Post operative Skiagram at 3 months showing collapse of the fracture site (note: after external fixator removal at 7 weeks)

The degree of disability after distal end radius fracture has been seen to correlate with the amount of residual deformity. Treatment options include closed reduction and pinning, bridging and non-bridging external fixation and open reduction with dynamic compression plate (DCP), precontoured locking and non locking plates and screw fixation through a variety of approaches [8].

Failure to reduce intra-articular fractures of the distal radius predisposes to pain, restricted movement and degenerative arthritis. Malposition is related to the radial height, radial angle, volar tilt and the accuracy of intra-articular reduction. Knirk and Jupiter found that radiological arthritis developed in 91% of wrists which had any degree of articular step and in all of those with a step greater than 2 mm [9].

In the treatment of comminuted distal radius intra articular fractures, surgeons may encounter serious complications such as difficult reduction and stabilization, loss of reduction, limitation of range of movement, post traumatic arthritis of the wrist. A brief classification should be made before treating the distal radial fractures. Among various classification systems, the AO classification system is the most suitable one because it reflects the severity of the fracture and helps the surgeon and the patient to know the possible outcomes [10].

The use of an external fixator alone or in conjunction with percutaneous or limited internal fixation, for unstable fractures of the distal end of the radius has produced good or excellent results. Early removal of the fixator allows early range-of-motion exercises and to avoid complications commonly associated with the prolonged use of external fixators [11].

Anatomic reduction with stable fixation is the treatment of choice for displaced intra-articular fractures of the distal part of the radius. The operative treatment goals are the prevention of radial shortening, malunion, and articular incongruity because these factors have been reported to be associated with poor outcomes and an increased risk of development of posttraumatic arthritis. Over the past decade, there has been increasing interest in plate fixation, especially volar plate fixation, of distal radial fractures [12].

In our study, no significant differences were found in long-term results of palmar locking plate and external fixation in intra-articular distal radius fractures. Functional assessment showed that at three months period the plate fixation was better but at six months there was no any significant difference.

The patients in the plate group had early return to function than the external fixator. The superior mobility achieved with the palmer locking plates may be attributed to the fact that these patients could start wrist movements earlier due to firm fixation [13]. The study by DH Wei et al. concluded that locked volar plate predictably leads to better patient-reported outcomes (DASH scores) in the first three months after fixation. However, at six months and one year, the outcomes of both the techniques were found to be excellent. In their study, the mean DASH score at six weeks for the patients with a volar plate was significantly better than that for the patients treated with external fixation (p value = 0.037). At three months, the patients with a volar plate demonstrated a DASH score that was significantly better than the patients treated with external fixation (p =

0.028). At six months and one year, both groups had DASH scores comparable with those for the normal population [14]. The same findings were seen in a study by A Gereli et al. The mean Quick DASH score was 2.4 ± 3.0 in the palmar locking plate group, and 2.9 ± 5.4 in the external fixation group [13].

According to Demerit score functionally and radiologically plate group had better score, the findings were statistically significant in three months period (p value= 0.009), but did not show any significance at six months period (p value=0.076).

Grip strength measured with the help of a dynamometer showed that the patients in the plate group showed better grip strength than the external fixator group. The findings were statistically significant at three months (p value= 0.022) in patients whose dominant hand was involved but at six months there was no statistical significance. Most patients with the non-dominant hand injured showed loss of grip power. Petersen et al. said that there is 10% difference in maximal voluntary isometric contraction of grip power between dominant and non-dominant hand. Hand dominance is one of the important factors for the treatment of fractures of distal end of radius [15].

Radiographically, it was shown that palmar plating was associated with better correction of palmar angulations. This may be explained by the fact that distraction primarily occurs via palmar structures and that palmar locking plate provides a better support to the fracture. Traction alone in external fixation cannot correct palmar angulations due to the fact that ligamentotaxis primarily functions through strong palmar links [13]. Several other studies showed that restoration of the radial length is the most important factor in achieving a good end result [16,17]. H Kapoor et al. reported that open reduction and internal fixation provided the best anatomical restoration with patients less likely to develop arthritis in future [18]. MJ Richard et al. found that the external fixation group demonstrated radial shortening of 0.72 mm in the interval between the first postoperative and final postoperative follow-up radiograph and the volar plate fixation group demonstrated only 0.27mm of radial shortening during the postoperative period. He concluded that volar plate fixation provides an overall decreased incidence of radial shortening [19].

Reflex sympathetic dystrophy, fixation loss, pin tract infections, injury to the sensory branch of the radial nerve, and joint stiffness in the wrist are among known complications of external fixation. Excessive distraction of the external fixator and prolonged fixation has adverse effects on the surgical treatment of distal radius fractures and can lead to many complications [20]. The study by BK Chan et al. also found similar findings [21].

In a study by TD Rozental et al. the complication rate was 8.7% in the open reduction and internal fixation group as compared with 27% in the closed reduction and percutaneous pin fixation group [22]. The study by MJ Richard et al. also concluded that there was an overall decreased incidence of complications in the volar plate group as compared to the external fixator group [19].

The use of palmar locking plate has become increasingly popular in recent years. Despite its advantages, there are still fracture types where palmar locking plate cannot be applied. Especially in comminuted very distal fractures that do not allow screw insertion, K-wire augmented external fixation may yield successful results. In such fractures, however, external fixation and distraction alone cannot adequately reduce free intra-articular fragments that do not respond to ligamentotaxis. In these cases, open reduction with mini incision allows restoration of joint surface. Fixing the reduced fragments with additional K-wires provide additional stability and speeds fracture union. The contemporary approach to intra-articular distal radius fractures is to determine the best fracture-specific treatment method, with consideration of the main goals.

In our study, we found that palmar locking plate fixation was both reliable and had low level of complications. It was also associated with higher levels of patient satisfaction. Objective and subjective functional assessments, on the other hand, showed no significant superiority between K-wire augmented external fixation and palmar locking plate fixation. Since the follow up was of short duration, long term outcomes could not be evaluated to further support the results.

V. Conclusion

We conclude that treatment with open reduction and internal fixation for intra articular fractures of distal end of radius provides good radiological results. However, objective and subjective functional assessment showed no significant superiority between external fixation and volar plate fixation at 6 months follow-up. Volar plate fixation also provides an overall decreased rate of complications when compared to external fixation.

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