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A Comparative Study on the Results of Distal Radius Intraarticular Fractures Treated Primarily with Volar Locking Plates vs Closed Reduction and Fixation with External Fixator and K-Wires

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ABSTRACT:Distal Radius fractures are among the most common orthopaedic injuries. Its treatment has evolved over the course of time leading to improvement in fracture stability and outcome. The aim of this study was to compare functional, clinical and radiological outcomes achieved by Ligamentotaxis with External fixator (with or without K-wire augmentation) & ORIF with contoured Volar locking Plate of intraarticular fractures of distal radius.This prospective comparative study was conducted at a tertiary care institute in Kolkata. Sixty patients were randomly divided into two groups, Group A(n=30) treated with ligamentotaxis and group B(n=30) treated with ORIF. The two groups were compared at six months in terms of radiological parameters i.e., radial height, radial inclination, ulnar variance and volar tilt; and functional parameters i.e., palmar flexion, dorsiflexion, pronation, supination, ulnar deviation, pain and grip strength. Subgroups of fracture by Fernandez classification were compared by age groups. The result was evaluated by Quick DASH and Gartland and Werley Score. For statistical analysis, Chi Square test, unpaired t- test and mixed effect model was used.The overall radiological parameters were comparatively better in plating group. The Grip Strength, pain score and Quick DASH were comparable. Gartland and Werley score showed more excellent result in ORIF group.Although the radiological results were slightly better with plating, there was no difference in functional outcome. Ligamentotaxis is suited for elderly patients due to less operative time and less soft tissue handling.

KEYWORDS: Intraarticular distal radius fracture, ligamentotaxis, ORIF.

I. INTRODUCTION

Fractures of distal end of radius are one of the most common fracture representing approximately 16% i.e. one-sixth of all fractures treated by orthopaedic surgeons. [1,2] Abraham Colles described this fracture in 1814 first time in the elderly population. [3] There is a bimodal age distribution of Distal end of radius3 fractures, consisting of a younger group who sustains relatively high energy trauma and an elderly group, who sustain insufficiency fractures. [4] Some of the factors predisposing to fracture of distal end radius includes advancing age, decreased Bone Mineral Density (osteoporosis), and associated co-morbidities. The timing of surgical intervention is critical as the fracture fragment start getting sticky and it is difficult to achieve desired reduction as well as radial length in case of delayed treatment. The modality of treatment depends on the fracture configuration and to some extent on age of the patient. The radiological acceptance criteria are intraarticular step off or gap <2 mm, Radial shortening <5 mm, Radial inclination >15° and between 10° dorsal tilt and 20° volar tilt. [4]

Closed reduction with cast immobilisation is still the mainstay of treatment for Distal radius fracture. [5] Subsequent loss of reduction is the major complication. [6,7] Percutaneous pining alone is often difficult in case of severely comminuted fracture. [8] External fixation, is an excellent mean of overcoming the displacing forces of the forearm muscles[5]. Open reduction and internal fixation involves opening the fracture site by a surgical approach based on type of fracture and fixing it with a variety of plates. Buttress plate can be applied either ventrally or dorsally or even at radial column. But this technique is also not without problems, since it cannot hold reduction well, in severely comminuted fracture. [4,9] Dorsal support is provided

best by placing the pegs inclined in a proximal-volar to distal-dorsal direction in the lateral plane and by fanning them out which closely follow the complex 3-dimensional shape of the articular surface. The inclination of the pegs in the lateral plane neutralizes dorsal displacing forces while inducing a volar force.[6] In the past 25 years, there has been dramatic evidence that function is intimately related to malunion in distal radial fractures. Intra- and extraarticular malunion have both been shown to decrease function and lessen patient satisfaction. [10-12]

This prospective study was carried out to evaluate the functional, clinical and radiological outcome achieved by closed reduction and ligamentotaxis by an external fixator with or without K-wire augmentation and open reduction and internal fixation with fixed angle contoured volar locking plate.

II. MATERIALS AND METHODS

This prospective comparative study was conducted in a tertiary care institute from January 2016 to June 2016. A clearance from Ethical Committee and Scientific committee of the Institute was obtained. Written informed consent was obtained from the patient or guardian for participation.

Inclusion criteria

1. 20-80 years age group of either sex.
2. Intraarticular fracture of Distal End of Radius operated within 10 days.
3. No reinjury over an old fracture in the vicinity of wrist.

Exclusion criteria

1. Pathological fractures
2. Open fractures
3. Associated with other injuries around wrist joint or neurovascular deficit.

Sample size and method: The quick DASH, our primary outcome measure, was used to perform an a priori power analysis. A meaningful difference in the quick DASH was estimated to be 10 points. [13,14] Recent studies of external fixation and volar plate fixation of the distal part of the radius showing the standard deviation of DASH scores to range from 5 to 10 points allowed for a more accurate power analysis. [15-17] We estimated that at least 30 patients per arm of the study were necessary to detect difference, with an 90% power. By simple random sampling ,60 patients were divided in two groups:

Group A: 30 patients treated with external fixator with or without K- wire fixation.

Group B: 30 patients treated with ORIF with contoured volar locking plate.

Cases were evaluated with a detailed clinical history, physical examination and local examination of the injured side.

X-Ray films were studied for Fracture classification as per Fernandez type by two observers.

Operation was done under per-operative radiographic control after regional or general anaesthesia in supine posture

Group A: Wrist spanning ex-fix with Joshi's external fixator, metacarpal Schanz screws of size 2.5 mm, radial Schanz screws of size 3.5 mm and K-wire sizes 1.5 to 2.0mm(non-threaded) was done following standard surgical technique (Figure 1).

Group B: ORIF was done through modified Henry's approach. Contoured Volar locking plate of varying length, drill bit and sleeve system, 3.5 mm screws, 2.7 mm locking screws and tap were applied following standard technique (Figure 2).

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Figure 1. Ex-fix application and post op function of patient

Figure 2. Volar plating steps and post op outcome

Post-operative care and Physiotherapy

Check X-Rays were taken in both anteroposterior and lateral views on post-operative day one. Active exercises of fingers and thumb were commenced from day of operation. Sutures were removed at post-operative day 14. Removal of the Fixator and K-wires was done under analgesia at 6

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weeks post-op or earlier depending on fracture pattern and pin loosening.

Patient were followed up clinically at 2,6,12,18 and 24 weeks. Radiological assessments of fracture union, dorsal tilt, radial shortening was done. Grip strength was evaluated at 6 months with a dynamometer. Wrist ROM i.e pronation, supination, palmar and dorsiflexion and radial and ulnar deviation were assessed by goniometer. Quick DASH score and Gartland and Werley score of all patients were evaluated at 6 months by single observer (SM).

Statistics

Categorical variables were expressed as number and percentage of patients and compared using Chi Square test. Continuous variables were expressed as Mean and Standard Deviation and compared using unpaired t test for normally distributed data and Mann-Whitney U test for non-normal distribution. Effect size was estimated with Cohen's d for continuous and Cramer's V for categorical variables. Mixed model analysis with Restricted Maximum Likelihood and unstructured covariance was performed for Quick DASH Score to compare age groups and Fernandez types. Significance was set at $p<0.05$. The statistical software SPSS version 25 was used for the analysis.

III. RESULTS

The two two groups were comparable regarding age, sex distribution, side of injury and Fernandez classification. The average duration of surgery was significantly lower in Group A. (Table 1).

Table 1. Comparison of Demographic and operative parameters for the two groups

Variable	Group		p-value(Cohen's d/ Cramer's V))
	A: Ex-fix± K-wire (n=30)	B: Volar plating (n=30)	
Age (Mean± SD) years	49.1±11.6	49.9±13.4	0.805(-.07)
Gender M(%) F(%))	 18(60%) 12(40%)	 18(60%) 12(40%)	1(0)
Side of injury Right(%) Left(%))	 11(36.6%) 19(63.4%)	 13(43.3%) 17(56.7%)	0.5(.06)
Mode of injury Domestic fall(%) High velocity injury(%)	 17(56.7%) 13(43.3%)	 25(83.3%) 5(16.7%)	0.02*(.55)
Fernandez classification II(%) III(%) IV(%) V(%)	 7(23.3) 12(40) 6(20) 5(16.7)	 7(23.3) 13(43.3) 5(16.7) 5(16.7)	0.98(.05)
Duration of surgery(Min)(Mean±SD)	42.1±9.5	69.7±9.3	<.001*(-1.64)

*Statistically significant

The two groups had significant difference in VAS score at 3rd post-op day, radial length, supination and ulnar deviation. Pain score and functional outcome and other radiologic parameters and wrist ROM were comparable in the two groups at 6 months.(Table 2)

Table 2. Comparison of outcome variable among the two groups

Variable	Group		p-value(Cohen's d/ Cramer's V))
	A: Ex-fix± K-wire(n=30)	B: Volar plating(n=30)	

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Pain score(VAS)(Mean±SD) Day 3 Week 1 Week 2 6 month	 4.7±1.1 2.8±0.6 1.3±0.5 0.2±0.4	 5.4±0.9 2.7±0.6 1.4±0.5 0.1±0.4	 0.01*(-.7) 0.51(.2) 0.43(-.2) 0.75(.1)
Grip strength(No, %) 60-80% opposite >80% opposite	 12(40%) 18(60%)	 9(30%) 21(70%)	 0.42(.1)
Quick DASH score(Mean±SD) Week 18 Week 20 6 months	 16.5±1.5 14.5±0.8 12.7±1.2	 16.6±1.8 14±3.5 11.9±2.1	 0.82(-.1) 0.4(.03) 0.7(.58)
Gartland and Werley score(count(%)) Excellent Good Fair	 11(37%) 14(47%) 5(17%)	 16(53%) 9(30%) 5(17%)	 0.36(.2)
Radial length(mm)(Mean±SD)	8.73±1.11	9.47±0.82	0.005*(-.7)
Radial inclination(deg)(Mean±SD)	17.7±2.1	17.8±2.7	0.916(-.03)
Volar tilt(deg)(Mean±SD)	5.4±1.5	5.6±3.1	0.706(-.1)
Ulnar variance(mm)(Mean±SD)	-1.53±0.7	-1.8±0.7	0.158(.36)
Palmar flexion(deg)(Mean±SD)	61.2±7.2	63.9±7.2	0.149(-.37)
Dorsiflexion(deg)(Mean±SD)	59.8±10.6	58.8±6.8	0.656(.12)
Pronation(deg)(Mean±SD)	58.9±7.2	58±6.8	0.620(.13)
Supination(deg)(Mean±SD)	64.6±6.6	67.9±3.8	0.018*(-.6)
Ulnar deviation(deg)(Mean±SD)	19.7±7.8	26.7±6.7	0.000*(-.8)
Radial deviation(Deg)(Mean±SD)	11.9±3	12.5±3.6	0.487(-.2)
Complication rate(%)	20%	6.67%	0.12(1.05)

*Statistically significant

A subgroup analysis with mixed effect model taking Fernandez type and age group as fixed effect parameters was done to compare the quick DASH score at 6 months in the two groups (AIC=137.7) (Table 3). The interactions Fixation type X Fernandez type was significant (F(3,36) =7.7, p<.001). The interaction Fixation type X age group was also significant (F(2,36)=4.2, p=0.02). Post- hoc pairwise comparison showed Quick DASH was significantly less favouring Volar plating in Type II and III fractures and younger age. While Ex-fix group showed significantly less score in Type V fractures and in older age group.

Table 3. Comparison of adjusted mean±SE of quick DASH in subgroups with respect to age and Fernandez classification.

Age Group	Fixation group	Fernandez type			
		II	III	IV	V

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21-40	A: Ex-fix± K-wire	13±0.8	13±0.5	13±0,8	13±1.2
	B: Volar plating	10.5±0.8	10±0.6	14±1.2	13±1.2
	p-value	.008*	<.001*	.338	1
41-60	A: Ex-fix± K-wire	13±0.7	13.5±0.6	11±0.8	14.5±0.8
	B: Volar plating	10±0.6	11.6±0.5	12±0.8	13±0.8
	p-value	<.001*	.003*	.290	.113
61-80	A: Ex-fix± K-wire	12±0.8	12.6±0.7	11±0.8	12±0.8
	B: Volar plating	10±1.2	12.2±0.6	14.5±0.8	14.5±0.8
	p-value	.084	.564	<.001*	.008*

*Statistically significant

Major complications in Group A were pin-tract infection in three patients which resolved after fixator removal, superficial radial nerve injury in two patients and over-distraction in one patient which was corrected at follow up. Complications observed with ORIF were FPL tendon irritation in one patient and superficial wound infection in one patient.

IV. DISCUSSION

The aim of the treatment of intra-articular distal radius fracture is to have a near anatomical alignment with minimal soft tissue stripping, stable fixation and early movement in order to have a functional, painless wrist movement with no deformity. In spite of the advancements of the treatment the quest for ideal management for individual fractures still continues.

The mean age in most of the studies is around 60 years but in the present study the mean age was 49.1±11.6 years in ex-fix and 49.9±13.4 years in ORIF group. The younger population has different characteristics and more functional demands. Orbey and Fernandez et al,[18] advocates open reduction and internal fixation with plate in younger people while Moroni and Vannini et al supports external fixator application in elderly with osteopenic bone. [19] There were more males in both our groups. Owen et al concluded that women suffered from Colles fracture six times as often as men. [2] Our study due to hospital population and non-randomisation may have biased distribution. All of our patients were right dominant and left side injury was more common. Orbey and Fernandez et al had left preponderance. [18] Predominant mode of injury was fall on outstretched hand similar to previous studies. [18] Type III fracture predominated, followed by Type II. In most of previous studies AO type C fractures were considered.

Mean time of surgery was less for ex-fix. With ORIF, surgeon needs to be more meticulous in dissection of tissues, fracture reduction, application of plate and wound closure. VAS score was comparable in both the groups at sixth month follow up. However, it was more for the plating group at 3rd post op day possibly due to more dissection. Orbey and Fernandez et alin their study found that at six weeks those with indirect reduction i.e. external fixation, had significantly more pain compared with patients who had an open procedure but at six months pain score was comparable in both groups with better function in the external fixation group. [18]Margaliot et altoo in a meta-analysis of external fixation and internal fixation did not detect clinically or statistically significant difference in pain rated outcomes between the two treatment modalities. [20]

In the present study the quick DASH score at 24 weeks for Distractor group was 12.7±1.2 and 11.9±2.1 for plating group. Study by Wilkinsen et alhad mean quick DASH 14 in ex-fix and 13 in ORIF groups at 26 week. [12] The difference was not significant statistically (p=0.7). Our study showed more excellent result in plating group but more good result in External fixator group. However, this difference was not significant(p=0.365). A longer follow up might have changed proportion of the outcome categories. Besides there is consensus that wrist function progressively improves up to 2 years. [21]

The overall radiological parameters were comparatively better in plating group, however statistical difference failed to occur except in radial height. Wrist ROM in terms of supination and ulnar deviation favoured ORIF while other movement

were comparable at 6 months. Previous studies have had similar findings. [22]

The overall complication rate has been reported as low as 9.6 percent. [23] Pin tract infection fortunately had low incidence which can be attributed to adequate fracture reduction prior to placing pins and open technique of pin insertion, so the soft tissue damage was minimal and post op cover dressing was done as advocated by Raskin and Melone,[24] who had no pin tract infection in their study. Neuropathy involving superficial radial nerve is a common occurrence following external fixator application. We had two cases with paraesthesia at the distribution of superficial branch of Radial nerve which did not resolve at six months. Studies have reported neuropathies in the distribution of the Superficial Radial Nerve, de-spite using an open technique which ranged from 0 percent to 16.7 percent. [25,26] Overdistraction during external fixation has been implicated in producing worse digital motion, worse functional outcome and worse strength and pain scores following fracture treatment.[1] One of the 30 patients of external fixation group radiologically was overdistracted which was corrected postoperatively. The fact that there is no threshold for overdistraction makes it difficult to demonstrate a strict causal relationship. One of the 30 patients in ORIF group developed signs of inflammation on third postoperative day over the operated wrist but fortunately it was superficial infection which resolved with wound debridement. Flexor tendon ruptures have been reported more frequently as a complication of volar plating. Yu et al found 15 percent of tendon complications caused by attrition due to protruding tips of distal screws. [27] This emphasizes the need for accuracy in the measurement and placement of the locked distal screws. In our study we found one tendon related complication. According to Drobetz and Kutscha-Lissbergrupture of Flexor Pollicis Longus is the most frequent complication of volar plate fixation, occurring in 12% of patients. [28] Secondary loss of fixation is relevant when a marginal fracture of the volar lunate facet is present. Harness et al in their study, [18] lost fixation of a volar lunate facet fragment, in seven patients with subsequent carpal displacement after volar plate fixation. In our series there were no such loss of fixation. With the exception of this particular type of fracture, loss of fixation on volar plating using the modern fixation devices, seems to be rare and may be related with improper indication or imperfect surgical reduction. Carpal tunnel syndrome has been described in association with volar plating but may occur in distal radius fractures independent of the method of treatment used. Other complications described occasionally in literature such as compartment syndrome, [18] breakage of plate or vascular injury, [29] were not observed. Our study had limitation of short follow-up.

V. CONCLUSIONS

This study provides evidence that distal radius intra-articular fractures can be successfully treated with volar plating as well as with external fixation with equal success. Although the radiological results are slightly better with plating, there was no difference in functional outcome at 6 months. Volar plate is preferred for young patients who require quick return of function and in Fernandez III fractures. External fixation is preferred in elderly and more comminuted fractures as it requires less operative duration and less soft tissue handling. Both the modalities of treatments were accompanied by complications.

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