

Functional Outcome of Displaced Intra-articular Fractures of the Distal Radius: Comparison of Closed Reduction Percutaneous Pinning with or without External Fixation versus Open Reduction Plate Fixation

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ABSTRACT

Objectives. The purpose of the study was to determine the outcomes of closed reduction percutaneous pinning (CRPP) with or without external fixation (EF) with open reduction and internal fixation (ORIF) using plate and screws.

Methods. Outcomes of ORIF versus CRPP, with or without external fixation for intra-articular distal radius fractures were compared through a multicenter, non-randomized, ambispective cohort study. A validated Filipino version of the DASH score (FIL-DASH) was used as primary outcome measure.

Results. The ORIF group consisted of 13 patients and the CRPP group, eight patients. Pain scores, post-operative complications and radiographic measurements were also evaluated. Mean FIL-DASH score for the ORIF group (M=26.69, SD=4.88) was significantly higher versus the CRPP group (M=14.59, SD=10.64; $t(19)=3.58$, $p=0.002$). No significant differences in radiologic parameters, pain scores, and complications were found.

Conclusion. The study demonstrates that functional outcomes post-CRPP with or without external fixation compares favorably over ORIF for distal radius fractures at one-year post-surgery.

Keywords: closed reduction pinning, DASH, distal radius fracture, internal fixation, plating

INTRODUCTION

Distal radius fractures are among the most common types of upper extremity fractures. They occur in a bi-modal distribution and account for a significant percentage of emergency room visits.¹⁻³

The current standard of management for intra-articular distal radius fractures is closed reduction, percutaneous pinning (CRPP). Advantages include faster surgical time, lower costs, and comparable results in terms of long-term functional outcome when compared to more invasive methods. Disadvantages include more complications, such as higher infection rates and deterioration of radiographic parameters over time.⁴⁻⁶

Open reduction and internal fixation (ORIF) has been shown to produce better DASH and Mayo scores, faster return to function, and consistency of anatomic reduction within the first few months of surgery, coupled with lower

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reoperation and complication rates.^{7,8} Disadvantages include longer operation time and higher expenses associated with surgery. In a developing country such as the Philippines, socioeconomic considerations greatly influence treatment selection.^{5,9}

The approach to management of distal radius fractures (DRFs) has slowly shifted in favor of open fixation, despite short-term studies showing no significant difference between the two treatment methods.¹⁰⁻¹⁴ While such trends can have a substantial impact for DRF treatment in the local setting, few studies are available. Determining treatment and functional outcomes may help facilitate formulation of management recommendations applicable to the Philippine population.

METHODS

Population and Sample

The sample size computation for this comparative, non-randomized multi-center cohort consisted of determining the MCID (minimal clinically important difference) between two DASH scores, and the effect size (ES). The sample size estimate for each group with an alpha of 0.05, having a power of 0.80 to detect a mean difference of 10.1 DASH score points between the two groups was 48 participants per group.¹⁵

All skeletally mature individuals aged 18 years old and above, able to answer patient-reported questionnaires and diagnosed with a displaced intra-articular fracture of the distal radius treated by either CRPP with or without EF (wrist spanning or not) and ORIF with plate fixation (volar or dorsal) from 2013-2016 were included in the study. A follow-up period of 12 months post-surgery was set for all patients, initially numbering 77 individuals. Patients diagnosed with open fractures, multiple injuries apart from DRFs (including bilateral DRFs), impaired wrist function or neurologic status prior to injury, and with known bone metabolism disorders or wound healing problems were excluded to minimize confounders, increase homogeneity and maximize reproducibility of results. Twenty-one patients (13 for the ORIF group and 8 for the CRPP/ExFix group) qualified for assessment and data analysis (Figure 1).

Consent was requested from treating surgeons at two tertiary institutions for inclusion of their respective patients. The primary author and clinic secretaries were familiarized with administration of the ICF (informed consent form) and the Filipino DASH (FIL DASH) in order to minimize bias. Data on patients with DRFs were reviewed. All subjects treated for DRFs before the study period who fulfilled inclusion and exclusion criteria were included in the retrospective data collection. Identified patients were contacted for follow-up by the clinic secretary and preliminary consent was secured. Consenting patients were then oriented and scheduled for follow-up, whereby FIL DASH questionnaires were completed by the patient. Prospective data collection was accomplished by reviewing

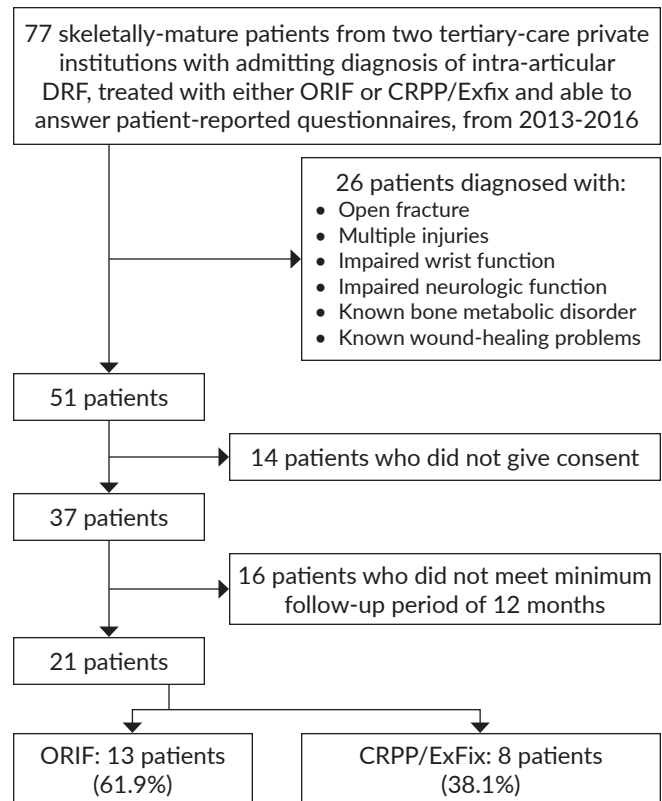


Figure 1. Study diagram.

all patients admitted with DRFs treated surgically using ORIF or CRPP/external fixation. Once eligible for the study, the same procedure for assessment was followed.

Medical records and surgical databases were used to collect all relevant data, ensuring strict anonymity. No attempt on blinding was done for the primary author, clinic secretary, patient, and statistician. Patients who withdrew or were lost to follow-up while conducting the study were replaced by new admissions fulfilling inclusion/exclusion criteria.

Outcome measures

The primary outcome measure consisted of the FIL DASH score. The FIL DASH is a translation based on the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire. It is a validated outcome measure consisting of self-reported questions designed to measure upper extremity disability and symptoms. The DASH score ranges from 0 to 100, with higher scores indicating greater levels of disability.^{14,16,17} Scoring was completed at three months post-surgery and on final follow-up, ensuring at least 12 months interval between intervention and the latter.

Assessment of secondary outcomes consisted of pain measured using two parameters, the Visual Analogue Scale (VAS) for pain and the Brief Pain inventory scale (BPI), which measures pain severity. VAS scoring consists of patient-reported symptoms selected from a scale of 0 to 100 mm, with "0" being no pain, and "100 mm" as the worst pain

imaginable during use of the involved wrist. The BPI is a tool used to assess pain and its impact on daily functions, reported in terms of pain and interference scores.

The BPI short form was used, consisting of nine questions covering pain severity and functional interference. Scores range from “0” to “10” for each section, with increasing values depicting more pain or disability.

Radiologic parameters were compared between the two groups prior to and following surgery, and on final follow-up. Values measured included radial height, radial tilt/inclination, volar tilt and ulnar variance, using standard radiographs. Incidence of complications on final follow-up were also recorded.

Data Analysis

Patients were categorized into two groups: those who underwent ORIF, and those who underwent CRPP with and without external fixation, or ExFix (CRPP/ExFix). Continuous data was tested for normality using the Shapiro-

Wilk test and compared between the two cohorts using Student’s T-test. Categorical data were compared using Fisher’s exact test. The level of significance for all tests was set at $p \leq 0.05$.

RESULTS

Twenty-one patients met our inclusion criteria, of which 61.9% underwent open reduction plating (ORIF), and 38.1% underwent either closed reduction, percutaneous pinning, or external fixation with or without augmentation (CRPP/ExFix). Table 1 summarizes the demographic and fracture characteristics of the study population. Thirteen patients were managed with ORIF with plate and screws and 8 patients were managed with CRPP with and without EF. Majority of patients were diagnosed with AO type C fractures (n=16, 76.2%), with the remaining having AO type B fractures (n=5, 23.8%). The two groups were found to be comparable at baseline across the following variables: La Fontaine criteria (age over 60 years, dorsal angulation over 20 degrees, presence of dorsal comminution, ulnar fracture, and intra-articular radiocarpal fracture), and AO fracture subtype (1, 2, or 3).

Table 2 compares radiologic parameters measured for both intervention groups prior to and after surgery. All pre-operative values were comparable between the two groups except for articular step-off, which was larger for the ORIF group. The immediate radiologic parameter was similar for both groups except for the radial inclination. On final follow-up, there was no significant difference in terms of radiologic parameters between the two treatment groups.

Mean differences between radiologic parameters taken post-surgery and on final follow-up within each treatment group were also obtained to determine loss of reduction. A smaller mean difference was noted for ORIF compared to CRPP/ExFix for all parameters (radial height, 0.58 [CI 0.23-0.93] versus 1.83 [CI 0.82-2.78]; radial inclination, 1.65 [CI 1.02-2.27] versus 1.93 [CI 0.83-3.02]; dorsal angulation, 0.37 [CI -2.30-3.03] versus 3.39 [CI -2.65-9.43]; ulnar variance, 0.092 [CI -0.25-0.44] versus -0.41 [CI -1.04-0.22]; and articular stepoff, -0.15 [CI -0.38-0.07] versus 0.40 [CI -0.13-0.93] (Table 2).

Table 1. Demographic and Fracture Characteristics of the Study Population

	ORIF ^a patients	CRPP/ExFix ^b patients
Number of patients per cohort	13	8
Age: mean (range)	50.1 (32-68)	52 (25-68)
AO type B	3	2
Subtype 1	-	-
Subtype 2	1	1
Subtype 3	2	1
AO type C	10	6
Subtype 1	3	2
Subtype 2	4	3
Subtype 3	3	1
LaFontaine criteria		
Age over 60 years (n, %)	2 (15.38)	3 (37.5)
Dorsal angulation >20 degrees (n, %)	4 (30.77)	2 (25.0)
Dorsal comminution (n, %)	9 (69.23)	2 (25.0)
Ulnar fracture (n, %)	7 (53.85)	4 (50.0)
Intra-articular radiocarpal fracture (n, %)	13 (100.0)	8 (100.0)

^a Open Reduction, Internal Fixation (All patients had volar locked plating)

^b Closed Reduction, Percutaneous Pinning/ External Fixation (only 1 patient had additional application of External fixation)

Table 2. Comparison of Radiologic Parameters between the Two Cohorts before Surgery, immediately Post-surgery, and on Final Follow-up

Radiologic parameter (Measurements)	Prior to surgery			Post-surgery			Final follow-up		
	ORIF Mean (SD)	CRPP/ExFix Mean (SD)	P	ORIF Mean (SD)	CRPP/ExFix Mean (SD)	P	ORIF Mean (SD)	CRPP/ExFix Mean (SD)	P
Radial height (mm)	4.62 (3.58)	5.99 (2.46)	0.35	8.19 (2.46)	9.63 (3.07)	0.25	7.68 (0.65)	7.7 (2.67)	0.99
Radial inclination (degrees)	15.78 (6.19)	17.6 (3.99)	0.47	22.85 (2.95)	19.75 (3.78)	0.05 ^b	20.55 (5.15)	16.85 (4.05)	0.10
Dorsal angulation (degrees)	8.81 (25.11)	16.4 (10.81)	0.43	2.92 (5.58)	2.85 (3.44)	0.97	3.25 (2.44)	2.13 (1.69)	0.10
Ulnar variance (mm)	1.66 (2.25)	1.5 (1.63)	0.86	0.02 (1.81)	0.25 (2.25)	0.80	-0.18 (2.03)	0.48 (2.33)	0.50
Articular gap (mm)	1.89 (1.58)	0.825 (1.03)	0.11	0 (0.0)	0 (0.0)	-	0 (0.0)	0.13 (0.35)	0.21
Articular step-off (mm)	1.92 (1.55)	0.53 (0.95)	0.03 ^a	0 (0.0)	0.13 (0.35)	0.21	0.32 (0.62)	0.35 (0.95)	0.55

Table 3. Comparison of Cases Managed by Hand Surgeon and Type/Incidence of Post-operative Complications

	ORIF	CRPP/ExFix	P value ^a
<i>Procedure done by hand surgeon (n, %)</i>	8 (61.54)	0 (0)	0.007
<i>Post-operative pain / paresthesia (n, %)</i>	1 (7.69)	2 (25)	0.53

^a Values derived using Fisher's exact test, with significant values italicized

Table 4. Comparison of Patient-reported outcomes: Primary (FIL DASH ^a / DASH ^b score) and Secondary Measures (BPI ^c score and VAS ^d)

	ORIF Mean (SD)	CRPP/ExFix Mean (SD)	P value
Primary outcome measure			
DASH score	26.69 (4.88)	14.59 (10.64)	0.002
Secondary outcome measures			
BPI score	0.052 (0.19)	0.036 (0.10)	0.82
VAS	0.38 (1.12)	0.50 (0.76)	0.80

^a FILIPINO DASH; translation based on Disabilities of the Arm, Shoulder, and Hand questionnaire; score ranges from 0 to 100, with higher scores indicating greater levels of disability

^b Disabilities of the Arm, Shoulder, and Hand; scores range from 0 to 100, with higher scores indicating greater levels of disability

^c Brief Pain Inventory scale; scores range from 0 to 10, with increasing scores depicting more pain or disability

^d Visual Analogue Scale for pain; scale of 0-10, with 0 being no pain, and 10 as the worst pain imaginable

There were fewer cases done by a hand surgeon in our study population (n=8, 38.1%) compared to those managed by non-hand surgeons (n=13, 61.9%), with all of them opting for ORIF regardless of fracture configuration (Table 3).

No significant difference was found between the two groups on the incidence of pain or paresthesia. Overall, more patients said they would not undergo the same procedure again (n=14, 66.7% vs n=7, 33.3%), with 84.6% of them in the ORIF group (Table 3).

A significantly higher DASH score was noted on final follow-up for the ORIF group compared to the CRPP/ExFix group [(M=26.69, SD=4.88 versus M=14.59, SD=10.64, respectively; $t(19) = 3.58, p=0.002$]. No significant difference in terms of Brief Pain Inventory Score [(M=0.052, SD=0.19 versus M=0.036, SD=0.10), $t(19) = 0.23, p=0.82$] and Visual Analogue Scale [(M=0.38, SD=1.12 versus M=0.50, SD=0.76), $t(19) = 0.26, p=0.80$] were noted (Table 4).

DISCUSSION

The study found no significant difference in terms of radiologic parameters, Brief Pain Inventory score, and VAS score on final follow-up between the two treatment groups. On comparing the mean differences between radiologic parameters taken post-surgery and on final follow-up within each treatment group, ORIF was found to be more effective at maintaining reduction overall compared to

CRPP/ExFix. Similar findings were reported in five meta-analyses conducted on a total of 44 RCTs from 2011-2013, all of which revealed no advantage on performing ORIF over CRPP in terms of DASH score, functional status, and radiologic measurements at one-year post-surgery.¹⁸⁻²²

Our results reflect the results of five randomized controlled trials conducted separately from 2009 to 2014, which showed no significant difference between the two methods in terms of DASH scores, functional outcome, and radiologic parameters at 3, 6, and 12 months post-operatively. Two of these trials however, included extra-articular DRFs, which may potentially have better functional results overall compared to intra-articular fractures.^{12,13} Our study addressed this issue by including only partial-articular and articular fracture configurations, using the AO classification.

The findings in this study of a significantly higher DASH score for the ORIF group compared to the CRPP/ExFix group indicates more disability-related symptoms for patients who underwent open fixation. Possible reasons for this include more extensive surgical dissection and longer operative times associated with ORIF versus CRPP/ExFix for distal radius fractures,⁴ factors which are beyond the limits of our present study but may warrant further investigation. Another consideration is the tendency for more complex fracture patterns to be indicated for ORIF from the outset, secondary to factors inherent to the fracture itself – greater derangement of radiologic parameters, increased pain related to the mechanism of injury, and difficulty maintaining alignment in osteoporotic or severely-comminuted bone.^{12,22} While supported by our data to a certain extent, the comparability of baseline characteristics including fracture type and all but one of the pre-operative radiologic measurements between the two groups supports the validity of our findings.

Overall, there were fewer patients managed by a hand surgeon in our population (n=8, 38.1%) compared to those operated on by non-hand surgeons (n=13, 61.9%). All subjects in this group were diagnosed with AO type C fractures, and all were indicated for ORIF regardless of fracture subtype. This is consistent with a 2016 study by Childs and colleagues,²³ where they found a higher proportion of complex, multi-fragmentary, and intra-articular distal radius fractures being referred to hand surgeons for management, with ORIF being the preferred method of intervention. Despite extensive analysis in foreign literature, few studies conducted on DRFs in the Philippine setting exist, with the most recent report by Estrella and colleagues in 2012. Their findings also found no advantage in terms of radiologic outcomes, grip strength, and post-operative pain between ORIF and CRPP at 1 year.⁷

The current standard of management for distal radius fractures remains closed reduction with percutaneous pinning. Despite these recommendations, the trend in management of DRFs has slowly shifted in favor of open fixation, from just 3% in the late 1990's to 16% in 2005.^{14,24} Such a shift in treatment strategy can have a substantial impact on the

future management of DRFs. A 2013 US study⁵ estimated the total cost per case of open fixation at \$1637.27, versus just \$733.91 for closed reduction pinning. In a developing country such as the Philippines where the minimum wage for a typical worker in the National Capital Region is roughly equivalent to \$11 a day,⁹ such statistics suggest a significant impact for patients, where healthcare-related costs remain prohibitive.

Our study sought to determine whether the incidence of post-operative pain, functional disability, and radiologic parameters would be significantly different among patients with intra-articular distal radius fractures treated with ORIF over CRPP/ExFix.

A larger sample size with more consistent, regular follow-up is recommended to closely monitor and compare short-term as well as long-term outcomes among the reported patient population, and to minimize bias associated with prospective cohort studies.

Limitations

Limitations of the study include a small sample size and utilization of outcome measures other than the DASH score, which has been identified as the best standardized instrument for evaluating patients with multiple upper limb joint disorders.²⁵ The small sample size of this study was the main drawback in making a conclusion for our results. Inherent to cohort studies is the tendency for selection bias and attrition bias. Difficulty with consistent long-term follow-up is also a frequent problem encountered in the local setting, particularly among patients in private, tertiary-care institutions.

The study design consisted of a non-randomized, comparative cohort, more feasible given the invasive nature of the intervention/independent variable tested (ORIF versus CRPP/ExFix). While the intervention was not controlled, the value of the study can be seen in its ability to periodically assess study subjects in a clinical setting, with a set of standardized parameters ensuring comparability and reproducibility of results. While a randomized controlled trial remains the standard of treatment for measuring treatment effect in terms of short- and long-term outcomes, employing such a research design for surgical interventions remains difficult particularly in low-resource settings such as the Philippines, where patient accrual and standardization in surgical technique remain obstacles to achieving high validity.

CONCLUSION

Despite extensive research in foreign and other Asian countries, Philippine data on distal radius fractures as well as comparative studies on open reduction, internal fixation versus closed reduction pinning with external fixation methods as treatment options remain scarce. While CRPP remains the current standard of management and has proven

to be comparable in terms of long-term outcomes in DRF patients, the current trend for management is shifting to ORIF regardless of patient age and fracture characteristics.

Our findings suggest that while radiologic parameters, pain scores, and incidence of complications were similar, closed reduction, percutaneous pinning with or without use of external fixation compares favorably to open reduction, internal fixation in terms of functional outcomes at 1-year post-surgery, among patients with intra-articular distal radius fractures.

Statement of Authorship

ART contributed in the conceptualization of work, data acquisition and analysis, drafting and revising, and final approval of the version to be published; EPE contributed in the research conception, design, and revision.

Author Disclosure

Both authors declared no conflicts of interest.

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