Radiographic Evaluation of Extra-Articular Distal Radial Fractures Treated With Closed Reduction Percutaneous Pinning Versus Closed Reduction Casting

Oliver M Atanacio, M.D., Renato D. Lipana Jr. M.D.,
Ferdinand P. Autea, M.D., F.P.O.A.

Department of Orthopaedics and Traumatology
Jose R. Reyes Memorial Medical Center, Manila
Philippines

ABSTRACT

Thirty patients with displaced extra-articular distal radial fractures were randomly treated with closed reduction/pinning with K-wires/casting and closed reduction casting only. Radiographic evaluation was done serially by one radiologist using the radial height (length), radial tilt (inclination) and palmar tilt to assess the degree of displacement for the two treatment groups. The advantages and disadvantages were also noted and recorded. Univariate ANOVA with covariate, Mann-Whitney and Friedman statistics showed that closed reduction pinning/ casting is more effective than closed reduction and casting alone in maintaining anatomical reduction hence preventing the incidence of re-displacement. Closed reduction and casting has a significant degree of loss of reduction. Both treatment groups are safe with low incidence of complications

INTRODUCTION

Distal radial fractures are the most common fractures seen in Orthopaedics constituting 16% of all fractures treated in the emergency room and up to 75% of all fractures in the forearm[1]. They are characterized by bimodal age distribution with the first peak in adolescence and second in the sixty to seventh decade. Accurate reduction, whether it be closed or open techniques, is correlated with prognosis[9]. The fracture pattern, degree of displacement and stability of the fracture are factors that determine whether surgical treatment is necessary. Radial inclination, volar tilt, radial height, and amount of comminution are all standard methods to measure and determine existing and potential instability[15].

Displaced extra-articular distal radial fractures are most commonly treated with closed reduction and application of a cast to support fracture healing. This method offers the benefits of simplicity, low cost and wide distribution of necessary material and skills for application. However, a small percentage of recent studies in the literature has focused on steps to diminish the incidence of re-displacement of the fracture after successful anatomic reduction in the cast. This may be attributed to motion of the fracture fragment secondary to the muscle deforming forces acting due to poor casting techniques and subsidence of swelling. Although the cast provide support, it will not completely maintain a reduction in 24 to 30%[9]. That is, a satisfactory reduction is more likely to re-angle and or displace when using a circular cast. Re-reduction of distal radius fractures is a practice of questionable benefit[9]. Some support for this practice is likely present in every medical community. But the value of such a practice must be measured against the risk necessary in order to regain reduction.

The addition of pins to enhance fixation of a cast is not new. Percutaneous pin fixation has been described by a multitude of authors[10]. However, no local study has compared one method to another in a meaningful fashion. Pin fixation has several advantages such as ease of pin fixation, the widespread availability of the necessary equipment, and the comparatively more secure stabilization of redisplaced fractures when compared to casting alone. Clancey et al[2] and Putnam et al[10] concluded that that percutaneous pin fixation with additional cast support (posterior splint) can maintain sufficient alignment and reduction so as to allow stable forearm rotation post-healing. Pin fixation to enhance the fixation of a closed circular cast (pins and plaster) has been effective for more than 50 years in treating unstable comminuted distal radial fractures. However, it has all the advantages of external fixation without some of its disadvantages[2].

OBJECTIVES:

A. General Objective
To compare the effectiveness of the two methods of treatment in terms of maintenance of reduction using radiographic measurements.

B. Specific Objectives:
1. To compare the radiographic measurements of closed reduction percutaneous pinning/casting and closed reduction application of a circular cast in treating displaced extra-articular distal radial fractures.
2. To determine the specific advantages and disadvantages of these two treatment techniques.

Correspondence should be sent to :
Dr Oliver M Atanacio
Department of Orthopaedics and Traumatology
Jose R. Reyes Memorial Medical Center, Manila
Philippines

STUDY DESIGN:

Prospective randomized clinical trial (RCT). Randomization will be done by alternate blinded selection of treatment at the ER and OPD.

Statistics:

Univariate ANOVA with covariate (SPSS-Statistical Package for the Social Sciences).
Mann-Whitney
Friedman (STATXACT-5)
Ethical Consideration:
All patients are informed of their choice of the procedure as well as the possible complications of both as described above.

METHODS

Inclusion Criteria

All patients with displaced extra-articular distal radial fractures (18-65 y/o) seen for the first time at Jose Reyes Emergency Service Complex and at the Outpatient Department from January 17, 2002- October 20, 2002 were entered into a prospective randomized study (blinded consecutively numbered envelopes). Demographic profile of the patients are taken. A voluntary informed consent is taken from each patient prior to enrollment to the study. All patients with displaced extra-articular distal radial fractures (using the Frykmann Classification[8]) types I and II are admitted and closed reduction was done under general anesthesia (IV sedation) following strict aseptic techniques at the emergency room. One group is fixed percutaneously using two Kirschner wires 0.062 using the Clancey technique[3] after which a long arm circular cast is applied and the second group with closed reduction and application of long arm circular cast only with 3 point fixation as described by Sarmiento et al[15].

Exclusion Criteria

All neglected or malunited fractures of the distal radius (> 3 weeks).
All fractures with volar/dorsal comminution (one or both cortex intact).
Accompanying shaft fracture (radial or ulnar).
Open fractures.
Impending or with compartment syndrome.
Previous fracture of the distal radius
Carpal Fracture/dislocations

Radiographs are taken one week post-op to check for any re-displacement from the succeeding post-reduction films. Radiographs are taken at weeks three and six. Measurements are taken using the radial inclination (tilt), palmar tilt, and the radial height. Radiographs will be measured by a single radiologist. At four weeks, pins are removed from Group A and cast removed for Group B. Any re-displacement of the fracture is defined as change of any of the values of the above measurements using the weekly radiographs. All possible complications during the study will be recorded. For the Group A, these are pin tract infection, loss of reduction due to loss of fixation, tendon entrapment/ rupture, neurovascular injury, complications of general anesthesia (IV sedation). For Group B, these are compartment syndrome, skin irritation from the cast, loss of reduction due to subsidence of swelling or breakage of cast, limitation of ROM, and complications of general anesthesia.

Treatment:

Plaster Group

The fracture was manipulated into a satisfactory position while the patient was under general anesthesia. When anatomic reduction had been achieved, the fracture was immobilized in a long arm circular cast with the elbow in 90 degrees flexion, wrist in 20 degrees of palmar flexion and 10 degrees of ulnar deviation. The cast was applied based on the principles of closed plaster application. Patients were given instructions to mobilize their fingers and shoulder and were allowed to return home after radiographic and neurovascular examination.

Percutaneous Pinning and Plaster Group

Patients were admitted to the hospital and placed under general anesthesia during surgery. After reduction of the fracture, percutaneous transfixation with Kirschner wires was carried out under portable x-ray guidance. Two 0.062 mm Kirschner wires were inserted from the radial styloid proximally and toward the ulna.; then an additional K-wire was inserted from the ulnar side of the radius proximally and toward the radius. Placement of the pins was checked via roentgenographs to ensure that the pins were at the proper depth. If the reduction was deemed acceptable and the fracture stable, a long arm circular cast was applied in addition to the pins. Patients were given the same instructions to mobilize their fingers and shoulder and were discharged the following day after radiographic and neurovascular examination. Both pins and the cast were removed at four weeks.

Follow-up

Patients in both groups were followed up at one, three, four and six weeks. Standard PA and lateral x-ray views were obtained at the time of injury, post-reduction, one week, three weeks, and six weeks after the reduction of the fracture and were submitted to the radiologist for evaluation of measurements.

The study protocol stipulated that if the fracture had slipped to an unacceptable position by the first follow-up visit, it would be re-manipulated. An unacceptable position was defined as dorsal angulation of more than 10 degrees, volar angulation more than 20 degrees, loss of normal radial inclination more than 10 degrees or radial shortening of more than 3mm. Re-manipulation was to be performed under anesthesia where a new well-molded long arm circular cast will be applied.

Radiographic Evaluation

Three measurements from the plain films were obtained: Radial inclination, radial height, palmar (volar tilt) . A single radiologist was assigned to measure the x-ray films from the time of injury, post-reduction, and the succeeding follow-up films (week 1, week 3 and week 6 post-op).

The radial inclination was measured on the PA view and

describes an angle formed between a line drawn through the tip of the radial styloid and medial corner of the lunate facet and a line perpendicular to the long axis of the radius, normally 23 to 24 degrees. Palmar tilt is measured on the lateral view as the angle between the line representing the distal articular surface and a line perpendicular to the long axis of radius, normally 11 to 12 degrees. The radial height was measured on the PA view as the difference in length between the radius and ulna. This is measured by drawing two lines perpendicular to the long axis of radius, one tangential to the tip of radial styloid and the other tangential to the flat surface of the ulnar head. The normal distance between the two lines is 9 to 12 mm.

RESULTS

A total of 34 patients were enrolled into the study - 8 males and 26 females (5 males and 10 females for the pins and plaster group; 3 males and 16 females for the casting group). Three patients were lost to follow-up and one patient dropped out from the study because of non-compliance. These patients were excluded from the study; hence, a total of 30 patients were included, 22 females (73.3%) and 8 males (26.7%). Three are left handed (10%) and 27 (90% are right handed. Overall, the mean age is 50 (18-64). For the closed reduction/casting group (15), 12 (80%) are females and 3 are males (20%) (Table 1). Mean age is 55 (34-64) (Table 2). Most are right handed (93.3%) (Table 3). For the closed reduction/pinning group (15) , 10 (66.7%) are females and 5 (33.3%) are males (Table 4). Mean age is 45 (18-59) (Table 5). Most are right handed (86.7%) (Table 6).

Table 1. Closed reduction/casting (post-reduction)
Frequency distribution of patients according to gender (n=15)

Gender	Number	Percentage
Males	3	20%
Females	12	80%
Total	15	100%

Table 2. Closed reduction/casting (post-reduction)
Frequency distribution of patients according to age (n=15)

Age range (in years)	Number	Percentage
0-10	0	0%
11-20	0	0%
21-30	0	0%
31-40	1	6.66%
41-50	3	20.00%
51-60	7	46.67%
61-70	4	26.67%
Total	15	100%

Table 3. Closed reduction/casting (post-reduction)
Frequency distribution of patients according to handedness (n=15)

Handedness	Number	Percentage
Right	14	93.34%
Left	1	6.66%
Total	15	100%

Table 4. Closed reduction/percutaneous pinning (post-reduction)
Frequency distribution of patients according to gender (n=15)

Gender	Number	Percentage
Males	5	33.33%
Females	10	66.67%
Total	15	100%

Table 5. Closed reduction/percutaneous pinning (post-reduction)
Frequency distribution of patients according to age (n=15)

Age range (in years)	Number	Percentage
0-10	0	0%
11-20	1	6.66%
21-30	2	13.33%%
31-40	1	6.66%
41-50	4	26.67%
51-60	7	46.68%
61-70	0	0%
Total	15	100%

Table 6. Closed reduction/percutaneous pinning (post-reduction)
Frequency distribution of patients according to handedness (n=15)

Handedness	Number	Percentage
Right	13	86.67%
Left	2	13.33%
Total	15	100%

Using the Mann-Whitney test (level of significance $p<0.05$), there is no significant change in radial length from the post-reduction baseline to week 1 ($p=0.993$) to both casting group and casting/pinning group .Using the ANOVA with covariate (level of significance $p<0.05$), there is no significant change in radial length from post-reduction baseline to week 3 ($p=.110$) and baseline to week 6 ($p=.110$) to both casting group and casting/pinning group. (Figure 1) However, using the ANOVA with covariate (level of significance $p<0.05$), there is a significant difference

(decrease) in the radial tilt from the post-reduction (baseline) to week 1 (p=.004), baseline to week 3 (p=0.000) and baseline to week 6 (p=.001) in the casting group compared to the casting/pinning group. (Figure 2)

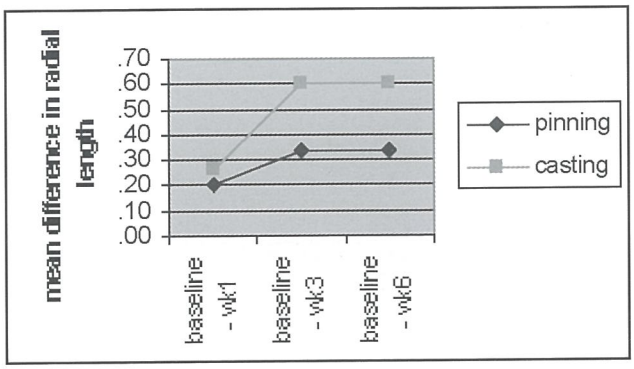

Figure 1. Change in radial length from baseline to six weeks.

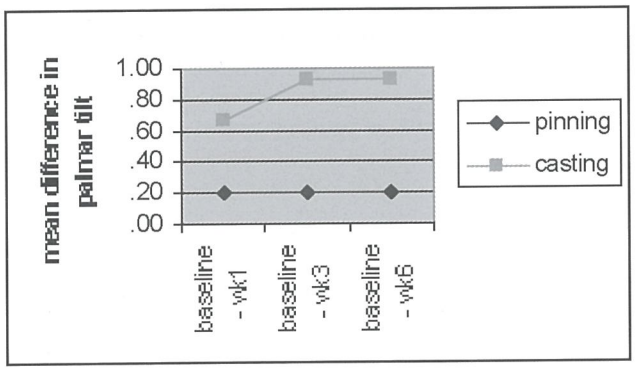

Figure 3. Change in palmar tilt from baseline to six weeks.

Using the Mann-Whitney test (level of significance p<0.05), there is a no significant difference in the palmar tilt from the baseline to week 1 (p=.093) in both casting group and pinning group . However there was a significant difference (decrease) in palmar tilt from baseline to week 3 (p=.026) and baseline to week 6 (p=.026) in the casting group compared to the casting/pinning group. (Figure 3)

In both treatment groups, initial displacement and the quality of reduction was identical. Seven days after the surgery, however, a significant loss of position was observed in five of the fractures (33%) of the plaster group. All refused a second reduction. Conversely, the fractures that had been stabilized with pins and plaster all maintained their initial reduction.

Pin tract infections occurred in one patient, fortunately; the infection was superficial and responded to treatment by cleansing and antibiotics. No joint infection nor osteomyelitis occurred. Tendon injuries and non-unions were not encountered in this study. In the plaster treated group, an angulated malunion was found in four fractures. All these patients had significant radiographic re-displacements at the first and third week post-reduction. All refused further remanipulation but were advised of the possible complications. No patient complained of median nerve neuropathy except for the two patients in two malunited fractures.

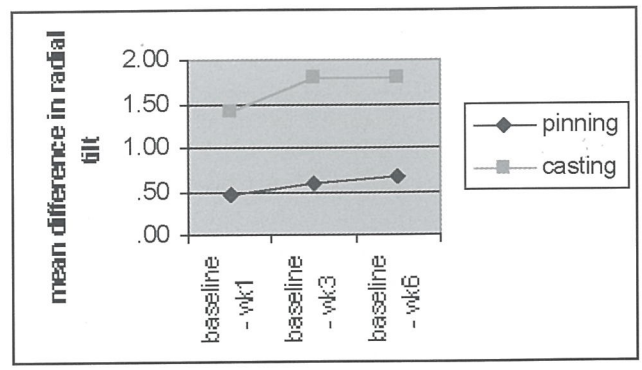

Figure 2. Change in radial tilt from baseline to six weeks.

DISCUSSION

In extra-articular distal radial fractures, the previously noted normal radiographic measurements are altered in a predictable fashion. The normal volar angulation is reversed or less commonly increases. Radial inclination diminishes with impaction. Even small amounts (2-3 mm) of radial shortening result in major changes in load transmission to the lunate fossa, the distal ulna and the TFCC[9]. In a cadaveric study, 3-10 mm of radial shortening resulted in 47% loss of pronation and 27% decrease in supination[10]. In our study, there was no significant difference in radial length in both groups but there was a significant change (decrease) in the radial tilt and palmar tilt for the casting group only.

The goals of treatment are to restore maximum function, maintain strength, limit development of posttraumatic arthritis and avoid complications. Non-surgical treatment with cast immobilization with or without manipulation is commonly used for extra-articular distal radius fractures. Some surgeons have observed that when distal radius fractures are treated conventionally with a plaster cast, loss of position after manipulation is almost inevitable[2]. Cooney et al[9] attributed their study's high complication rate (31%) to incomplete restoration of radial length and/or secondary loss of reduction position in many of their patients. Rodriguez-Merchan et al[11] believe that the loss of reduction in the plaster group was not due to inadequate cast application. In this study, cast application was similar in both groups, with a well-molded long arm circular cast based on the principles of cast application. Porter et al[4] have noted in a large series of older individuals an alarmingly high rate of major re-displacement of up to 60%. Such results have justifiably engendered a sense of pessimism regarding the ability of a cast treatment to maintain alignment post-manipulation in older patients. While the position and type of immobilization remain controversial, no study disputes the tendency of these fractures to lose position after reduction.

The frequently associated problem in percutaneous pinning is failure to achieve joint restoration despite length and angular restoration. In our study, anatomic reduction was achieved in 11(73%) cases up to six weeks follow-up with no change of position in the post-reduction film in the pins and plaster group while in the plaster group alone is there is no change in position up to six weeks post reduction in five cases (33%). The high rate of satisfactory results in our pins and plaster group supports the data

reported by Rodriguez et al. This study found that the best anatomic results were obtained by percutaneous pinning. Criteria for an acceptable reduction, and the optimum techniques to achieve and maintain it, are not clear for all fracture types in all age groups. The main extra-articular criteria include the palmar tilt, radial inclination and the radial height. Any loss of these have been implicated as causes of poor outcome as has articular incongruity. In this study, the radial tilt as well as the palmar tilt decreased significantly for the casting group at week one post reduction.

CONCLUSION

Although functional outcome was not measured in this study, the study results indicate that closed reduction with pinning and casting is more effective than closed reduction and casting alone in maintaining anatomical reduction. This study proved that the pins and plaster method is effective; hence this method is recommended for the treatment of displaced extra-articular distal radial fractures. Although the cost of pins and plaster is significantly greater than the plaster treatment, we believe that this will prevent re-displacement of the fracture and obviate another procedure to achieve anatomic reduction. We believe that the positive end result justifies the cost. Furthermore, pins and plaster method is a safe procedure with a low incidence of complications. Only one patient suffered pin tract infection which was successfully treated. Closed reduction and casting has a high incidence of loss of reduction which was significant 1 week post reduction and even up to the 3rd and 6th week post reduction. On the other hand, pins and plaster group has no significant loss of reduction from the baseline reduction.

RECOMMENDATIONS

Despite advances in fixation techniques, studies continue to report fair and poor outcomes after treatment. Thus, what seems clear is continuing and perhaps increasing need for better precision and predictability in dealing with this common fracture that has an ongoing history of imperfect results. We therefore recommend the following:

1. We recommend a larger group of patients in subsequent studies to be done.
2. To measure and compare the functional outcome of both treatment groups.
3. To test both treatments in intraarticular fractures.

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