



Closed Reduction and Percutaneous Kirschner Wire Fixation versus Open Reduction and Internal Fixation by Plate and Screws in Treatment Displaced Unstable Intra Articular Distal Radial Fractures

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ABSTRACT

Introduction: Fracture of distal radius comprises approximately one-sixth of all fractures. We managed 128 patients with closed dorsally displaced unstable intraarticular distal radial fractures (CDUIADRF), AO Type C, during the period between November 2011 and December 2016 (with a mean follow up of 18 months) at Al Sader Medical City Hospital (academic medical center) in Najaf, Iraq. **Patients and methods:** There were 64 cases treated by open reduction and internal fixation by volar locked plate and screws (ORIF) method and 64 treated by closed reduction and percutaneous Kirschner wires fixation (CRPKF) in 21-82 years old patients. The results were assessed clinically by Disabilities of the Arm, Shoulder and Hand scoring system (DASH) and radiologically by Lidström and Frykman classification. This classification is modified by Sarmiento, et al. **Results:** Regarding ORIF method, the outcome was excellent in 54%, good in 32%, and fair in 8% cases and poor in 6%, but with CRPKF method the outcome was excellent in 44%, good in 28%, fair in 14% and poor in 14%. **Conclusion:** We concluded that the open reduction and internal fixation by plate and screws method are superior to the closed reduction and percutaneous Kirschner wires fixation method.

Keywords: Radial fractures, Closed reduction, Percutaneous Kirschner wire fixation, Open reduction, Internal fixation

INTRODUCTION

The impact of distal radial fractures on society can be anticipated to increase over time, as a result, considerable scientific, clinical, and economic interest in the treatment of these fractures have developed. For several decades, treatment of distal radius fractures has been extensively reported on but the definite treatment of those fractures remains a subject of much debate. The indications for surgical management are obvious, but selecting the right method for fixation of distal radius fractures has been still an issue of controversy [1].

Incidence: Annually more than 600,000 distal radial fractures attends emergency units in the United States and forming one-sixth of all fractures seen there and 75% of fractures of the forearm [1]. It can occur at any age but it has bimodal peaks at 6 to 10 years of age and more than 60 years old. It is more common in females than males (3:1) [2].

Mechanism of injury: It usually results from low-energy trauma more frequently than from high-energy injuries [3]. Displaced intraarticular fractures are usually caused by the shearing and impaction forces which occur in high energy injuries and are usually seen in young or active elderly patients [4].

Many classification systems presents for distal radius fractures. Most classifications were based on the location of the fracture, a number of intra-articular fragments, and the direction of displacement and involvement of ulna [5]. Clinically, the patients were presented with the painful wrist, bruised, swollen and sometimes deformed. The skin should be examined for abrasions, laceration, and contusions [6]. The general aims of treatment are length restoration, preservation of articular congruity and radial inclination with the maintenance of the DRUJ to achieve best functional results with the prevention of osteoarthritis and symmetry of articular surfaces [7]. The exact anatomical reduction has the priority in the planning of the treatment. Therefore, the present study tried to compare the outcome of open reduction and internal fixation by anatomically shaped angular stable volar locked plate and screws method with

those after closed reduction and internal fixation by percutaneous Kirschner wires method in the treatment of closed dorsally displaced unstable intra-articular distal radial fractures.

MATERIALS AND METHODS

A prospective study was conducted during 2011 to 2015, including 128 cases aged 21-82 years with closed displaced unstable intraarticular distal radial fracture (CDUIADRF) at Al Sader Teaching Hospital (academic center) in Najaf, Iraq. In this study, we have selected only cases of CDUIADRF in a patient with age ranging from those who were otherwise healthy and carried no systemic diseases or illnesses. Out of the 128 cases, 84 sustained a closed displaced unstable intraarticular distal radial fracture on the right side (dominant side) and 44 cases sustained the same injury on the left side (non-dominant side). Patients were assigned into 2 groups with 64 cases in each group. Group 1 was managed with open reduction and plating was required. Group 2 managed with successful closed reduction and percutaneous fixation. All patients were followed up for an average period of 18 months.

Inclusion Criteria

Patient with closed displaced intra-articular distal radial fracture aged 21 to 82 years, of both genders, who agreed to participate and signed a written informed consent, and who planned to be operated on within an average of 8 days after injury, even when the fracture had displaced after another method of treatment such as external fixation or cast immobilization were included in the study.

Exclusion Criteria

The patient was excluded if he/she had one or more of the following criteria:

- Pre-existing medical disorders that affect bone physiology like a malignant tumor, hyperparathyroidism, vascular insufficiency of the upper limb, alcoholic or drug dependency
- Patients with polytrauma with an injury severity score 25 of more than 16 points
- Patients who were expected to be unable to participate and or unable to continue the follow-up, or involved in other clinical studies
- Pathological fractures
- History of previous distal radial fracture or subjected to previous surgery on the ipsilateral distal radius, open fractures, concurrent spinal cord injury, injury associated with brachial plexus and radial nerve palsies
- Pregnant women

Study Protocol

The patients with acute injury were first received either in the casualty unit or as an outpatient in the orthopedic clinic and diagnosed as a displaced distal radial fracture. The radial pulse and capillary refilling were examined. The patients were then transferred to the radiology department to perform X-ray in 2 views (posteroanterior and lateral views), and then the wrist was carefully placed in the POP back slab. A tight bandaging was avoided. Analgesia was given to the patients (tramadol tablets 50 mg for 2-3 days, then acetaminophen for 5-7 days). The arm was gently put in a sling. The patients were admitted to the orthopedic ward for definitive management. After approval of the ethics committee in our hospitals and complete explanation of the treatment plan to the patients and their close relatives, a written consent was taken from the patient. In the theater, an initial attempt of closed reduction was done for all our patients at first. All the patients were operated under general anesthesia with supine position, the upper limb lying out of the table, and was controlled by an assistant.

Under fluoroscopic guide, the fracture was manipulated to correct any displacement of the distal fragment. When the reduction was achieved, two K-wires were inserted at distal segment, first one through the styloid process and second through Lister tubercle, both of them were parallel to each other starting from distal to proximal, and both hitting far radial cortex. The generous skin incision was used to avoid skin tethering, and then the K-wires of 5 mm length was bent, cut and then placed subcutaneously, this method differs from Kapandji method who used intrafocal pinning [8]. The limb was placed in an above elbow backslap for 5-7 days, well-molded fiberglass cast for next 4-6 weeks, and the limb was placed in a sling for comfort. The exercise began from the second postoperative day which involves

the shoulder and small hand joints. The wrist with elbow exercise started immediately after the removal of cast and K-wires which was usually removed after 8-10 weeks. If closed reduction failed, we would shift to open reduction and plating. The preoperative antibiotics were given (single injection ceftriaxone 1 gram IV infusion within 1 hour before the operation) and used a pneumatic tourniquet. In the supine position of the patient, the arm was put on an arm board and was abducted approximately at 60°C. A 3.2 mm volar anatomical plate was used through a volar approach. The plate was previously measured on a contralateral X-ray image, all screws were placed through 2 cortices by the aid of fluoroscopy, the limb was put in an above elbow backslap for 5-7 days, and then fiberglass cast for next 4-6 weeks, and then the limb was placed in a sling for comfort with same physiotherapy protocols like CRPKF. Most of the patients were discharged at the next day and then the follow-up evaluations visit started, which were achieved at after 5 days, 10 days, 3 weeks, 6 weeks, 3 months, 6 months, 1 year, 18 months, 2 years, respectively. At each visit assessments of infection, nerve injury, pain, shoulder and elbow range of motion and grip strength, the standard radiographs, posteroanterior and lateral radiographs were noted and measured radiologically by Lidström and Frykman classification. This classification was modified by Sarmiento, et al. [9]. On the posteroanterior films, articular step-off and gap, radial angle, and radial length were measured. On the lateral film, articular step-off with a gap and palmar tilt were measured. The above measurements give the base of the radiological score which was used in this study. The data used for all patients in the study includes name, age, sex, date of injury, date of presentation, the cause of injury and any history of previous surgery. On examination, the following points were taken into consideration: which limb is injured, vascular injury, nerve injury. X-ray findings were reported, and any displacement and mode of treatment whether CRPKF or ORIF was checked.

Statistical Analysis

Statistical analysis was performed using the statistical package for social sciences version 22, SPSS, software for windows [10]. Descriptive statistics presented as mean, median, standard deviation, frequencies and proportions (%) [11]. For comparison of quantitative variables, the Mann-Whitney test was applied and for comparison of qualitative variables Chi-square test was applied, the level of significance was set at $p < 0.05$ as the cutoff point [12,13].

RESULTS

There were 128 cases enrolled in this study with a mean age of 52.6 ± 9.4 (range: 21-82) years, females were dominant, 82/128 represented 64.1% with a female to male ratio of 1.78 to 1. Regarding the cause of fracture, fall accounted for 52 (40.6%), car accidents 32 (25%), fall from height 30 (23.4%) and violence causing a fracture in 14 cases (11%). The operation was performed within the first week in 96 cases (75%), between 8 and 10 days following trauma in 32 cases (25%). Group 1 included 40 female and 24 male, and Group 2 included 42 female and 22 male they were assessed and sex distribution did not have a significant difference in either group. The median age in locking plate Group 1 and pin and plaster Group 2 was 51.8 and 52.2 years respectively (Table 1).

Table 1 Demographic characteristics of the studied group

Variable	No.	%	
Gender	Male	46	35.9%
	Female	82	64.1%
Cause of fracture	Fall	52	40.6%
	Car accidents	32	25.0%
	Fall from height	30	23.4%
	Violence	14	10.9%
Operation time post-trauma	With 7 days	96	75.0%
	8-10 days	32	25.0%

The results were assessed clinically by Disabilities of the Arm, Shoulder and Hand scoring system (DASH). This score has high reliability, validity, and internal consistency. The results were assessed radiologically by Lidström and Frykman classification which is modified by Sarmiento, et al., the end score was calculated, starting from 0 (no disability) to 100 (the most severe morbidity). So a higher score indicates greater disability.

As it is shown in, the mean union time depending on clinical and radiological signs of Group 1 was 8 weeks while that of Group 2 was 12 weeks (Tables 2 and 3).

Table 2 Evaluations of the results according to Disabilities of the Arm, Shoulder and Hand scoring system (DASH)

Parameters	Group I	Group II
Union time in weeks	8 weeks	12 weeks
Hospital stay (days) postoperatively	1	2
Loss of Range of motion in degrees for wrist	0	3
Pain	Mild	Moderate to severe
Strength in compared to other side	1	3

Table 3 Sarmiento's modification of Lindstrom criteria (anatomical evaluation)

Variables	Residual deformity	Loss of palmar Inclination	Residual shortening (mm)	Loss of radial Deviation
Excellent	No/insignificant	0°	<3	<5°
Good	Slight	1-10°	3-6	5-9°
Fair	Moderate	11-14°	7-11	10-14°
Poor	Severe	At least 15°	At least 12	>14°

The mean of hospital days for Group 1 as 1 day while that of Group 2 was 2 days. The mean of score regarding the range of motion in the wrist in Group 1 was 3 (excellent) and that of Group 2 was 2 (good). The mean of score regarding pain in Group 1 was 3 (absent) while that Group 2 was 2 (mild to moderate). The mean of score regarding strength (as compared to normal side) in Group 1 was 4 (excellent) while that of Group 2 was 3 (good). Delayed union of the fracture was reported in 18 cases, 6 of which were with ORIF method and 12 cases in CRPKF method. Non-union of the fracture was reported in 13 cases, 4 of which were with ORIF method and 9 cases in CRPKF method. All cases required bone grafting as additional operations and all fractures eventually united on follow-up. There were 8 cases of infection, 6 of which is pin tract infection in the CRPKF and tow cases as a superficial wound infection in ORIF method and all cases were treated with local care and an oral antibiotic. Superficial radial nerve injury occurred in CRPKF method which was spontaneously relieved within 3 weeks from onset of injury. Joint stiffness was reported in 18 cases, 4 of which were in CRPKF method, and 12 cases in ORIF method all of them were treated by physiotherapy as in Table 3.

As in Table 4, the score was excellent for 63 patients (35 with ORIF and 28 with CRPKF), good for 38 patients (20 cases with ORIF and 18 with CRPKF), fair for 14 patients (5 with ORIF and 9 with CRPKF), poor for 13 patients (4 with ORIF and 9 with CRPKF). Regarding flexion and supination of the wrist, there is an early benefit in the volar locking plate group (Tables 4-6). Chi-square test showed that the number of acceptable cases of volar tilt, articular surface step, radial inclination, and ulnar variance in the volar plate group was significantly greater. Also, in the plate group, the number of high-grade osteoarthritis was less.

Table 4 Disabilities of the arm, shoulder and hand scoring system (DASH)

Case Description	The Score	The Prognosis
Not limited at all	1	Excellent
Slight limited	2	Good
Moderate limited	3	Fair
Very limited	4	Poor
Unable	5	Very poor

Table 5 Postoperative complication

Type of complication	Patient treated by ORIF		Patient treated by CRPKF		p-value
	No.	%	No.	%	
Delayed union	6	9.00%	12	18.75%	0.127
Nonunion	4	6.25%	9	14.00%	0.143
Injury of superficial cutaneous branch of radial nerve	3	4.68%	0	0.00%	0.243
Wound infection(include pin tract infection)	2	3.00%	6	9.30%	0.273
Malunion	0	0.00%	0	0.00%	1.000
Joint stiffness	4	6.25%	12	18.60%	0.033

Table 6 Score of each method

Score	ORIF method	CRPKF method	p-value
Excellent	54%	44%	31%
Good	32%	28%	
Fair	8%	14%	
Poor	6%	14%	

DISCUSSION

Fractures of the distal radius have increased in frequency because of an aging population and the growth of participation of sports. Other contributing factors include osteoporosis and medical illnesses that affect a patient's risk of falling. Distal radial fracture is more common with predisposing factors such as loss of balance, osteoporosis, and a decrease in visual acuity [14]. Distal radial fractures are among the most common traumatic injuries that a primary clinician will see in the office or emergency department. When treating them, the goal should be to maintain wrist, elbow and shoulder function while achieving prompt fracture union. Stable internal fixation of upper arm fractures enabling early active mobilization [15]. CRPKF and ORIF by plate and screws is not a new methods for treatment of displaced closed distal radial fracture and it has been widely used by different surgeons with different results, the best of which is when the reduction was checked per-operatively before ending of all procedure and when the stable reduction is achieved and maintained [16,17]. Volar fixed-angle plate as a type of fixation method which provide a sound alternative method for distal radial fractures treatments because the volar side of the fracture is the stable side and the volar locked plate will be put in this side. The position of extensor tendons of the forearm which layed in direct contact with the posterior surface while the flexor tendons presents away from the volar surface of the distal radius, this renders even thick plate more accepted anteriorly [18].

Jupiter and Jesse in 2009 reviewed 102 patient with intraarticular distal radius fractures treated with same period of follow up, same clinical score Disabilities of the Arm, Shoulder, and Hand (DASH) scores, but with different radiological score, Gartland and Werley Score and they had a smaller number of patients, most of the patients ended with good functional outcome. They agree with our study as this states good-to-excellent outcomes with a limited incidence of complications with plate and screws fixation method [19,20].

Chung, et al., who had 161 patients with intra-articular displaced distal radial fracture treated by volar locked plate with same radiological parameters and clinically assessed by Michigan Hand Outcomes Questionnaire, they agree with our results as they state that volar plat provide stable fixation with less incidence of complications than other methods of fixation [16].

Chaudhry, et al., with his 875 patients meta-analysis study which include all distal radial fractures, they agree with our results in preferring volar locked plate fixation but only at 3 and 12 months follow-ups and after that period of follow up, there is clinically insignificance differences between two methods. He found more superficial wound infection in those fixed by K-wires alone and this agrees with our results [17]. Franceschi, et al., in their systemic review study of 1306 patients, who used same DASH score, found no differences between these two techniques regarding grip strength with ROM, radiographic variables with a total rate of complications. This systemic review study disagrees with our study [18].

Qiu, et al., in their study about the risk of postoperative complication following 7 types of treatment of distal radial fractures, agrees with our study in that volar plating provide sufficient stable fixation to give early mobilization [20].

Oshige, et al., did comparative study between volar plating and intrafocal percutaneous pinning in treatment of displaced distal radial fractures on 62 patients, depending on the grip strength and range of motion as a main clinical parameter, they conclude that the patients treated with volar locked plate had earlier recovery in grip strength and range of motion than those patients treated with intrafocal pinning. This study agrees with our study [21].

Bahari-Kashani, et al., did a study in 114 patients about the outcome of plaster and pin with volar plating in distal radial fractures using following clinical scoring systems DASH, MAYO, and SF-36. They agreed with our study as they stated that the volar plating in distal radial fractures may be of advantage [22].

Glickel et al., in his retrospective review study about outcome of treatment of distal radial fracture with closed

reduction and percutaneous pinning who take smaller sample than ours and relatively similar clinical and radiological scoring system, disagrees with our conclusion as he concludes that closed reduction and pinning is effective and low-cost method and long-term outcome was excellent [23].

Williksen, et al., Boyer, et al., Lee, et al., McFadyen, et al., and Hollevoet, et al., in their comparative studies between volar plating method and closed reduction with percutaneous pinning found similar results as they promoted to use the volar locked plate than another method although both studies took relatively smaller sample and longer follow up period [15,24-27].

CONCLUSION

We concluded that open reduction and internal fixation method is superior to closed reduction and percutaneous K-wire fixation as it is associated with less incidence of delayed union non-union, injury of a superficial cutaneous branch of the radial nerve, wound infection (include pin tract infection), malunion and joint stiffness.

DECLARATIONS

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Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

- [1] Shauver, Melissa J., et al. "Current and future national costs to medicare for the treatment of distal radius fracture in the elderly." *The Journal of Hand Surgery*, Vol. 36, No. 8, 2011, pp. 1282-87.
- [2] Radius, Distal, David S. Ruch, and Margaret M. McQueen. "Distal Radius and Ulna Fractures." 2010.
- [3] Lichtman, David M., et al. "Treatment of distal radius fractures." *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*, Vol. 18, No. 3, 2010, pp. 180-89.
- [4] Lichtman, David M., et al. "American Academy of Orthopaedic Surgeons clinical practice guideline on the treatment of distal radius fractures." *JBJS*, Vol. 93, No. 8, 2011 pp. 775-78.
- [5] Rozental, Tamara D., et al. "Functional outcomes for unstable distal radial fractures treated with open reduction and internal fixation or closed reduction and percutaneous fixation. A prospective randomized trial." *Journal of Bone and Joint Surgery*, Vol. 91, No. 8, 2009 pp. 1837-46.
- [6] Meena, Sanjay, et al. "Fractures of distal radius: an overview." *Journal of Family Medicine and Primary Care*, Vol. 3, No. 4, 2014, p. 325.
- [7] Korcek, L., and M. Wongworawat. "Evaluation of the safe zone for percutaneous Kirschner-wire placement in the distal radius: Cadaveric study." *Clinical Anatomy*, Vol. 24, No. 8, 2011, pp. 1005-09.
- [8] Kapandji, A. "Internal fixation by double intrafocal plate. Functional treatment of non-articular fractures of the lower end of the radius (author's transl)." *Annales de Chirurgie*, Vol. 30. No. 11-12, 1976.
- [9] Kennedy, C., et al. "Radiological outcomes of distal radius extra-articular fragility fractures treated with extra-focal Kirschner wires." *Injury*, Vol. 41, No. 6, 2010, pp. 639-42.
- [10] Rao, A., and Sandeep, K.N. "A Study on Management of Comminuted Colles Fracture by Closed Reduction and Ulnocarpal Stabilisation with 2 K-Wires." *IOSR Journal of Dental and Medical Sciences*, Vol. 14, No. 4, 2015, pp. 45-51.
- [11] Alm-Paulsen, Paal Sandoe, et al. "Percutaneous pinning of fractures of the distal radius." *Journal of Plastic Surgery and Hand Surgery*, Vol. 46, No. 3-4, 2012, pp. 195-99.
- [12] Lakshmanan, Palaniappan, et al. "Infection rate of percutaneous Kirschner wire fixation for distal radius fractures." *Journal of Orthopaedic Surgery*, Vol. 18, No. 1, 2010, pp. 85-86.

- [13] Chen, Yixin, et al. "Reliable techniques to avoid damaging the superficial radial nerve due to percutaneous Kirschner wire fixation of the distal radius fracture through the radial styloid process." *Surgical and Radiologic Anatomy*, Vol. 32, No. 8, 2010, pp. 711-17.
- [14] Karantana, Alexia, et al. "Surgical treatment of distal radial fractures with a volar locking plate versus conventional percutaneous methods: a randomized controlled trial." *JBJS*, Vol. 95, No. 19, 2013, pp. 1737-44.
- [15] McFadyen, I., et al. "Should unstable extra-articular distal radial fractures be treated with fixed-angle volar-locked plates or percutaneous Kirschner wires? A prospective randomized controlled trial." *Injury*, Vol. 42, No. 2, 2011, pp. 162-66.
- [16] Chung, Kevin C., Melissa J. Shauver, and John D. Birkmeyer. "Trends in the United States in the treatment of distal radial fractures in the elderly." *The Journal of Bone and Joint Surgery. American Volume*, Vol. 91, No. 8, 2009, p. 1868.
- [17] Chaudhry, Harman, et al. "Are volar locking plates superior to percutaneous K-wires for distal radius fractures? A meta-analysis." *Clinical Orthopaedics and Related Research*, Vol. 473, No. 9, 2015, pp. 3017-27.
- [18] Franceschi, Francesco, et al. "Volar locking plates versus K-wire/pin fixation for the treatment of distal radial fractures: a systematic review and quantitative synthesis." *British Medical Bulletin*, Vol. 115, No. 1, 2015, pp. 91-110.
- [19] Jupiter, Jesse B., and M. Marent-Huber. "Operative management of distal radial fractures with 2.4-millimeter locking plates: a multicenter prospective case series." *JBJS*, Vol. 91, No. 1, 2009, pp. 55-65.
- [20] Qiu, Wen-Jun, et al. "The comparative risk of developing postoperative complications in patients with distal radius fractures following different treatment modalities." *Scientific Reports*, Vol. 5, 2015, p. 15318.
- [21] Oshige, Toshihisa, et al. "A comparative study of clinical and radiological outcomes of dorsally angulated, unstable distal radius fractures in elderly patients: intrafocal pinning versus volar locking plating." *The Journal of Hand Surgery*, Vol. 32, No. 9, 2007, pp. 1385-92.
- [22] Bahari-Kashani, Mahmoud, et al. "Outcomes of pin and plaster versus locking plate in distal radius intraarticular fractures." *Trauma Monthly*, Vol. 17, No. 4, 2013, p. 380.
- [23] Glickel, Steven Z., et al. "Long-term outcomes of closed reduction and percutaneous pinning for the treatment of distal radius fractures." *The Journal of Hand Surgery*, Vol. 33, No. 10, 2008, pp. 1700-05.
- [24] Williksen, John H., et al. "External fixation and adjuvant pins versus volar locking plate fixation in unstable distal radius fractures: a randomized, controlled study with a 5-year follow-up." *The Journal of Hand Surgery*, Vol. 40, No. 7, 2015, pp. 1333-40.
- [25] Boyer, Martin. "Volar locking-plate and Kirschner-wire fixation did not differ in terms of functional outcomes after dorsally displaced distal radial fracture." *JBJS*, Vol. 97, No. 10, 2015, p. 859.
- [26] Lee, Yih-Shiunn, et al. "A comparative study of Colles' fractures in patients between fifty and seventy years of age: percutaneous K-wiring versus volar locking plating." *International Orthopaedics*, Vol. 36, No. 4, 2012, pp. 789-94.
- [27] Hollevoet, Nadine, et al. "Percutaneous K-wire fixation versus palmar plating with locking screws for Colles' fractures." *Acta Orthopaedica Belgica*, Vol. 77, No. 2, 2011, p. 180.