Treatment of distal radius fractures with percutaneous pinning

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Background
Distal radius fracture is one of the common injuries seen in casualty and can be managed by closed reduction and percutaneous pinning. The purpose of this prospective study was to determine the functional results following management of distal radius fractures by percutaneous wire fixation.
Materials and methods
This study was conducted between June 2014 and June 2017 and included seventy closed distal end radius fractures in 70 patients, comprising 40 (57.14%) males and 30 (42.86%) females. All were managed with closed reduction and percutaneous Kirschner wires fixation.
Results
The average follow-up was 18 months (range: 12–24 months). All the fractures healed within 10–14 weeks. A total of 36 (51.4%) cases got excellent score, 18 (25.7%) cases were good, 12 (17.1%) cases were fair, and four (5.7%) cases were poor. Most of the patients returned to their preinjury activity level with a 90.7% satisfaction rate. There were 10 cases that experienced pin tract infection and were treated by antibiotic.
Conclusion
Percutaneous pinning is a simple, minimally invasive technique and is aimed at preventing redisplacement of the distal radius fracture fragments to provide sound bone healing and achieve good radiological and functional results.

Keywords:
distal radius fracture, infection, percutaneous Kirschner wires fixation

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Introduction

Fractures of the distal radius are the most common of all orthopedic injuries accounting for nearly 16–20% of all fractures presenting to the emergency department [1,2]. Some surgeons advocate treatment by manipulation and plaster immobilization [3–5].

Malunion of distal radius fractures leads to post-traumatic arthritis, mid-carpal instability, and pain [6,7]. Conservative treatment of minimally displaced and stable fractures of distal end of radius in elderly patients usually shows a good outcome, but the treatment of severely displaced and unstable fractures has been controversial. The functional results in patients with significant radial shortening are poor [8].

The management of the distal radius fractures has undergone tremendous changes in the recent past owing to better understanding of pathological anatomy, mechanism of injury, and development of newer implants. The objective of treatment of distal radius fracture was to restore the anatomy of the wrist to obtain early painless function. Closed reduction and cast immobilization, percutaneous pin fixation, external fixator, volar locking plate, and intramedullary nail fixation have been used as a single or combined procedure in the management of distal radius fractures [9–11]. Closed reduction and percutaneous Kirschner wires (K-wire) fixation with plaster immobilization is one of the commonest modes of treatment employed in the management of distal radius fracture [12].

In most displaced fractures of the radius, loss of reduction is likely to occur unless accurate management is provided to prevent repeat displacement. Inadequate fixation might result in gradual shortening at the fracture site during the healing process, even with excellent reduction. Percutaneous pinning and casting are simple procedures familiar to most surgeons [13,14].

Materials and methods

This prospective study included 70 patients with distal radius fractures who were treated with percutaneous K-wire fixation. The patients received treatment at Suez Canal University hospital between June 2014 and June 2017.

Inclusion criteria

Patients with failure to achieve acceptable reduction (>15° of dorsal angulation, <15° of radial tilt, or >2.0 mm of radial shortening) or redisplacement within 2 weeks were enrolled into the study. Patients included were older than 18 years and of both sexes. Patients with osteoporosis were also included. Patients having intra-articular fracture without significant comminution, having articular step-off less than 2 mm, and having associated ulnar styloid process fractures were included as well.

Exclusion criteria

Patients who refused to participate and patients with open fractures, neurovascular compromise or pathological fractures, oblique volar fractures, die-punch fractures, and significant dorsal comminution involving more than one-third of the anteroposterior diameters of the radius were excluded.

Clearance from the medical ethical committee and formal informed consent from the patients were obtained before the procedure.

History, examination, investigations required by the anesthetist, and plain radiography in anteroposterior and lateral views of the wrist and forearm were obtained for all patients.

Preoperative radiographs were assessed for fracture pattern, degree of comminution, and articular fragmentation. All of the cases were evaluated by using the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification [15].

Operative technique

Procedure was carried out under general or regional anesthesia. Manipulation was processed to achieve acceptable reduction as the criteria mentioned before (Fig. 1). Two or three percutaneous K-wires were inserted, with the wrist in traction to maintain the reduction. Image intensification fluoroscopy was used to assist the reduction and to assess the accuracy of the reduction assist the insertion of the K-wires throughout the entire procedure.

The wires were drilled proximally through the radial styloid until they penetrated the intact cortex of the shaft. K-wires with a diameter between 1.2 and 1.6 mm were selected for use.

The ends of the wires were bent at a right angle and then cut short outside the skin, and a protective below elbow cast was applied for 6–8 weeks.

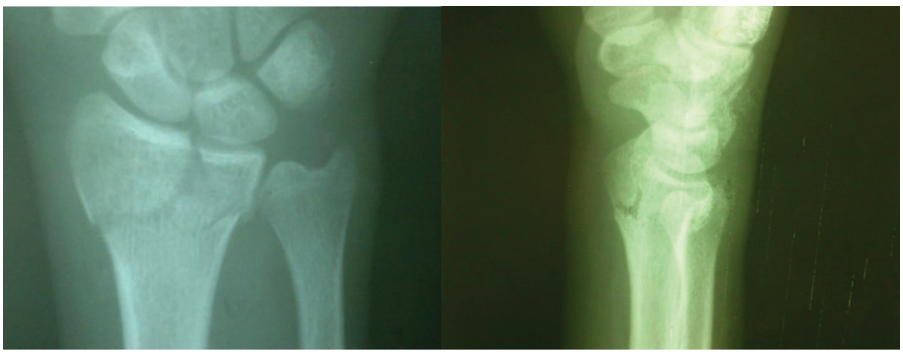
Postoperative check radiographies were taken (Fig. 2). Postoperatively the limb was kept elevated and discharge was planned on the next day after initiating shoulder, elbow, and finger mobilizations. Check radiographies were repeated at third, sixth, eighth, 10th, and 12th weeks to assess the fracture healing (Figs 3 and 4). Clinical and radiographic examination demonstrated progression of fracture healing. The percutaneous wires were usually removed after 4–6 weeks of immobilization, and the protective cast was removed 2 weeks after wires removal on an outpatient basis. Physical therapy was arranged, and a protective splint was applied after the removal of the cast for 2 weeks. Follow-up radiography was done every 3 months till 1 year postoperatively.

The loss of palmar tilt, radial tilt, and ulnar variance was measured from radiographs done before wire removal and later in follow-up (3–6 months after injury and ≥1 month after wire removal).

Outcome measures

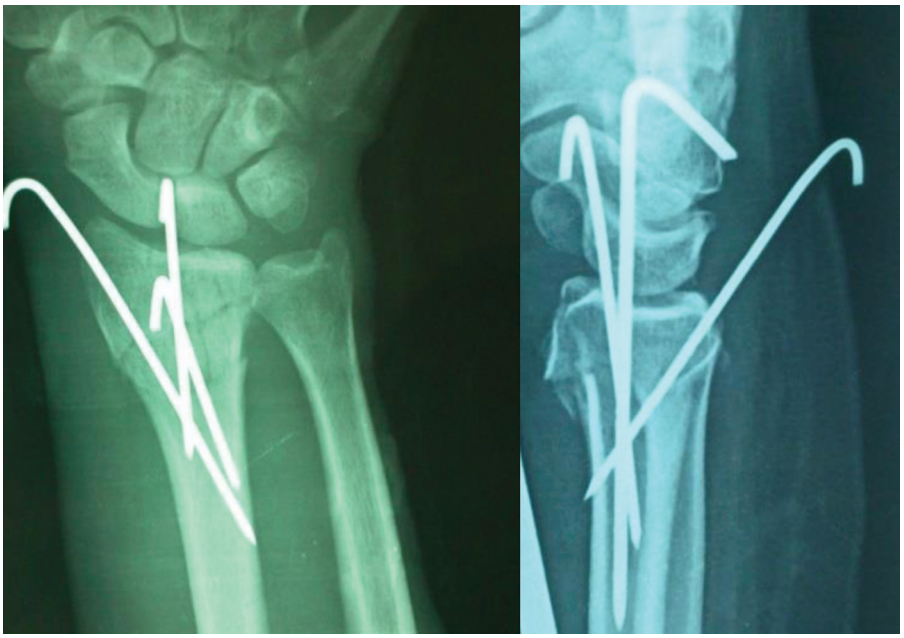
Two evaluation tools were used in this study. The Cooney modification of the Green and O'Brien score is an examiner-rated assessment of pain,

Figure 1



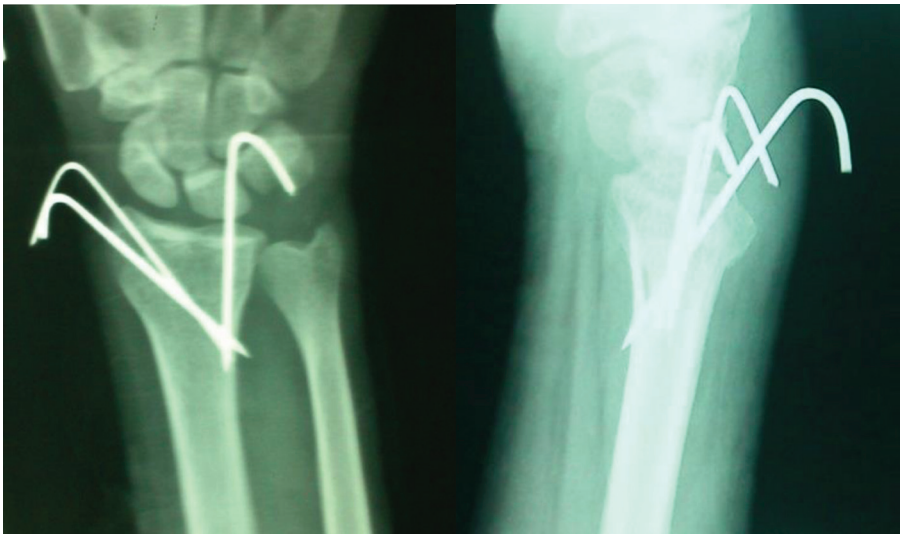
Posteroanterior and lateral radiography (postreduction distal radial fracture).

Figure 2



Posteroanterior and lateral radiography (direct postoperative distal radial fracture).

Figure 3

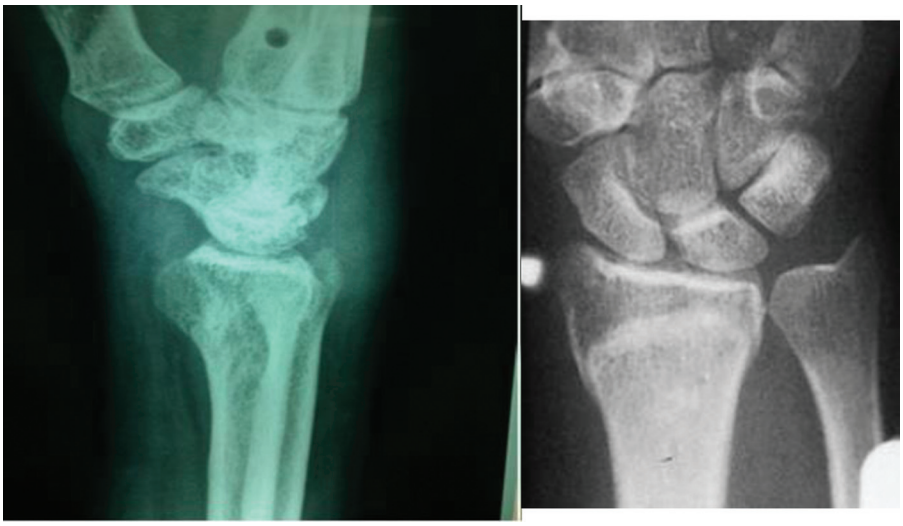


Posteroanterior and lateral radiography (distal radial fracture before pining wires removal).

functional status, range of motion, and grip strength. Each of the four parameters is given a weighting of 25 points, giving a total score of 100, with excellent being 90–100, good 80–89, fair 65–79, and poor less than 65. Radiographic evaluation included radial inclination: averages 23° (range: 13–30°), radial length: averages 11 mm (range: 8–18 mm), and Palmar (volar) tilt: averages 11–12° (range: 0–28°). Posteroanterior and lateral radiographs were taken at each follow-up visit, and measurements were recorded using the method developed by Kreder *et al.* [16]. On the posteroanterior films, radial length, radial angle, and articular step-off and gap were measured. On the lateral film, palmar tilt and articular step-off and gap were measured. A radiological score was derived from the aforementioned measurements – in this study, the modification of the Lidström and Frykman radiological classification by Sarmiento and colleagues was used [16–18].

Statistical analysis was done using SPSS version 22 software (SPSS Inc., Chicago, Illinois, USA). *P* value less than 0.05 was considered to be significant for the purpose of this study.

Figure 4



Posteroanterior and lateral radiography (united distal radial fracture).

Results

According to the AO classification, there were 40 patients with A2 fractures, 26 patients with A3 fractures, and four patients with B1 fractures, and all 70 patients sustained closed distal radius fractures. Age of the patients ranged from 18 to 63 years, with a mean of 45 years; 56 (80%) patients were from 20 to 50 years of age, and 14 (20%) patients were from above 50–63 years of age. A total of 40 (57.14%) patients were males and 30 (42.85%) patients were females. Of the 70 patients, 50 (71.42%) had right-side fracture and 15 (21.42%) patients had left-side fracture; 20 (28.57%) patients were housewives, 22 (31.42%) patients were manual workers, and 28 (40%) patients had different occupations; and 22 (31.42%) patients had fractures owing to road traffic accident and 48 (68.57%) patients owing to falling on an outstretched hand.

Patients with 0 day before intervention were 16 (22.85%), patients with 1 day before intervention were 16 (22.85%), patients with 2 days before intervention were 20 (28.75%), and patients with 3–7 days before intervention were 18 (25.71%).

Fractures were fixed within 1–7 days (mean: 3 days). A total of 65 (92.85%) patients were treated on the basis of 1 day surgery and discharged the next day from the hospital, and the other five (7.17%) patients stayed 1 week owing to associated injury. K-wires were removed in the outpatient clinic usually between 4 and 6 weeks, where 40 (57.2%) patients had K-wires removed after 4 weeks, 15 (21.4%) patients after 5 weeks, and 15 (21.4%) patients after 6 weeks postoperatively.

The mean of follow-up was 18 months (range: 12–24 months). All of the fractures healed in this study group (Fig. 2). All patients were followed up at the outpatient clinic.

A total of 50 (71.4%) patients had range of movements 70–100% of normal after 6 months; 20 (28.6%) patients had more limited flexion, extension, radial deviation, and ulnar deviation, and these results improved by physiotherapy, where only 14 (20%) patients had limitation of movement less than 70% of normal after 1 year. The wrist movement after the end of follow-up is shown in Table 1.

Sixty (85.7%) patients had full grip strength after 6 months and 10 (14.3%) patients had weak hand grip, and these results improved by physiotherapy, leaving only six (20%) patients with weak hand grip after 1 year (Table 2).

Assessment of postoperative radiographs showed that the average radial height was 11 mm (range: 7–15 mm). At the time of removal of pin-in-plaster and percutaneous K-wires, the average radial height was 10.5 mm (range: 7–15 mm; Table 3).

The average volar tilt was 8.5° (range: 5–12°) on immediate postoperative radiographs. At the time of removal of pin-in-plaster and percutaneous K-wires, the volar tilt was 8° (range: −5 to 12°; Table 4).

Fifty (71.4%) patients returned to full activity after 3 months and 60 (85.7%) patients returned to full activity from 3 to 6 months, and 68 (97.1%) patients returned to full activity after more than 6 months.

Table 1 The wrist movement after end of follow-up

	90–100% [*n* (%)]	80–89% [*n* (%)]	70–79% [*n* (%)]	60–69% [*n* (%)]	50–59% [*n* (%)]	<50% [*n* (%)]	Total [*n* (%)]
Wrist extension	36 (50.4)	14 (19.6)	6 (8.4)	8 (11.2)	4 (5.6)	2 (1.4)	70 (100)
Wrist flexion	32 (44.8)	16 (22.4)	8 (11.2)	7(9.8)	4 (5.6)	3 (4.2)	70 (100)
Radial deviation	36 (50.4)	13 (18.2)	7 (80)	8 (11.2)	4 (5.6)	2 (1.4)	70 (100)
Ulnar deviation	34 (47.6)	14 (19.6)	8 (11.2)	8 (11.2)	3 (4.2)	3 (4.2)	70 (100)
Forearm pronation	33 (46.2)	17 (23.8)	6 (8.4)	6 (8.4)	5 (7)	3 (4.2)	70 (100)
Forearm supination	33 (46.2)	13 (18.2)	10 (14)	8 (11.2)	4 (5.6)	2 (1.4)	70 (100)

Table 2 Grip assessment

% of grip	*n* (%)
75–100%	64 (91.4)
60–74%	4 (5.7)
50–59%	2 (2.9)
>50%	–
Total	70 (100)

Table 3 Degrees of radial height

	Immediate postoperative [*n* (%)]	At time of K-wires removal [*n* (%)]
Degrees of radial height		
9 mm	5 (7.1)	8 (11.4)
9.5 mm	8 (11.4)	9 (12.8)
10 mm	17 (24.3)	18 (25.7)
10.5 mm	15 (21.4)	14 (20.0)
11 mm	25 (35.7)	21 (30.0)

Thirty-six (51.4%) cases got excellent score, 18 (25.7%) cases were good, 12 (17.1%) cases were fair, and four (5.7%) cases were poor (Table 5), and the *P* value is significant.

The patients with poor assessment after 1 year are five (7.1%), the patients with fair assessment after 1 year are 14 (20.0%), the patients with good assessment after 1 year are 17 (24.3%), and the patients with excellent assessment after 1 year are 34 (48.6%), and the *P* value is significant (Table 5). Final score in relation to other parameters were assessed (Table 6).

There were four (5.7%) patients rated as poor, which correlated with radial shortening, especially on the step-off of the radioulna joints. Moreover, 10 (14.2%) cases complained of pin tract infection, which is better avoided by proper cleaning of pins, and this infection was mild and stopped after K-wires removal after union. A total of 14 (20%) cases had

Table 4 Volar tilt degrees

	Immediate postoperative [*n* (%)]	At time of K-wires removal [*n* (%)]
Degrees of volar tilt		
5°	5 (7.1)	5 (7.1)
6°	7 (10.0)	8 (11.4)
7°	12 (17.1)	14 (20,0)
8°	11 (15.7)	10 (14.2)
9°	19 (27.1)	18 (25.7)
10°	12 (17.1)	12 (17.1)
11°	2 (2.8)	2 (2.8)
12°	2 (2.8)	1 (1.4)

Sudeck's atrophy, and vitamin C together with early finger motion reduced the incidence markedly.

Discussion

Distal radial fractures are among the most common fractures encountered. These fractures are second only to hip fractures as the most frequent fragility fractures [19]. Considering the general increase in life expectancy of the population, the number of distal radial fractures can only be expected to increase in the coming decades. The importance of anatomic reduction has been demonstrated by clinical studies as well as by laboratory assessment of force and stress loading across the radiocarpal joint [19–21].

In fractures with articular surface displacement greater than 2 mm, radial shortening greater than 5 mm, or dorsal angulation more than 20°, suboptimal results have been reported in previously published studies [22–24]. Therefore, every effect should be made to restore normal length, alignment, and articular surface congruency of the distal radius. Generally, the treatment of distal radial fractures has been well documented in the literature. The decision of operative or nonoperative treatment is taken based on patient factors, the characteristics of the fracture, and implant availability. Factors including fracture

Table 5 Final assessment at 1 year postoperatively

Assessment after 1 year	*n* (%)	Clinical score		*P* value	Radiological score	*P* value
		Mean	SD		*n* (%)	
Poor	4 (5.7)	60.0	1.0	$<0.001^{\$,*}$	5 (7.1)	$<0.001^{\$,*}$
Fair	12 (17.1)	73.0	1.3		14 (20.0)	
Good	18 (25.7)	85.7	2.8		17 (24.3)	
Excellent	36 (51.4)	96.4	2.7		34 (48.6)	

$^{\#}$Mann–Whitney *U*-test. $^{\$}$Kruskal–Wallis test. *$P<0.05$, statistically significant.

Table 6 Final clinical score in relation to other parameters

Score assessment parameters	*n* (%)	Clinical core		*P* value
		Mean	SD	
Age (years)				
<50	56 (80)	85.5	7.0	$0.466^{\#}$
≥50	14 (20)	83.7	6.4	
Sex				
Male	40 (57.2)	84.3	7.8	$0.522^{\#}$
Female	30 (42.8)	86.6	5.1	
Styloid ulna fracture				
Present	26 (37.1)	80.2	6.6	$0.022^{\#,*}$
Absent	44 (62.9)	92.5	6.2	
Articular surface involvement				
Intra-articular	20 (28.6)	82.3	6.2	$0.202^{\#}$
Extra-articular	50 (71.4)	86.2	8.0	
Interval before intervention (days)				
<1	16 (22.85)	82.0	10.5	$0.394^{\$}$
1	16 (22.85)	90.6	4.3	
2	20 (28.75)	84.4	6.1	
3–7	18 (25.7)	83.0	5.2	
AO classification				
Type A2	40 (57.1)	86.6	5.3	$0.122^{\$}$
Type A3	26 (37.1)	90.8	6.9	
Type B1	4 (5.8)	81.4	9.3	

AO, Arbeitsgemeinschaft für Osteosynthesefragen. $^{\#}$Mann–Whitney *U*-test. $^{\$}$Kruskal–Wallis test. *$P<0.05$, statistically significant.

stability, intra-articular involvement, and joint congruency are all crucial for decision making [25]. However, it is important to acknowledge that most of the literature is based on findings in younger patients. When geriatric distal radial fractures are considered, the clear indications for operative treatment become more controversial and sometimes even contradictory. For young patients, stable fractures can be treated with cast immobilization after closed reduction with good to excellent results [26,27]. For unstable fractures that cannot be immobilized stably in a cast, operative treatment is preferred [9,28]. However, in elderly patients, fracture reduction, and anatomical alignment do not correlate with functional outcomes [17,29].

An accurate reduction in the fracture is the first step in the treatment of the distal radius fracture. After anatomic reduction in the fracture is achieved, many methods are available to maintain alignment and prevent repeat displacement. The methods of immobilization include casting, percutaneous pinning, external fixation, internal fixation with plate, or internal fixation combined with external fixation depending on the different types of fractures. Every method has its advantages and some limitations.

Three-point fixation with a well-fitted cast is essential for adequate immobilization. Moreover, cast immobilization alone cannot maintain distraction to correct length or control the rotation of the distal fragment when comminution is present [30,31]. Loss of reduction usually happens after 2 weeks of casting despite a perfect initial anatomic reduction. Gartland and Werley [22] obtained a 68.3% satisfactory result, and Sarmiento *et al.* [17] reported an 82% satisfactory result treated with the casting technique [32]. Spira and Weigl [30]. reported a 51.4% unsatisfactory result with reduction and use of cast in the treatment of comminuted fracture of distal radius with articular involvement [33]. Closed reduction and percutaneous pinning relies on intrafocal manipulation and pinning or manual traction, reduction,

and pinning to hold the fracture in an appropriate anatomic alignment. Clancey [12] reported a 96.4% satisfactory result in 30 patients treated with percutaneous pinning if the articular surface of the radius was not comminuted into more than two fragments [1]. However, the tenting effect is not strong enough in comminuted fracture, which often results in subsiding and dorsal angulation.

K-wires are placed through radial styloid and/or dorsally to aid in reduction. Alternatively they may be placed intrafocally as in Kapandji's technique [15]. This technique of cross pinning with two radial styloid pins and placement of a pin from the ulnar corner of the radius is described to be the most rigid construct biomechanically [34]. Secondary displacement after K-wire fixation is explained by residual instability owing to fracture comminution or osteoporosis. Correlation between anatomical and functional results is yet another controversial topic in treatment of these fractures. Most authors consider loss of radial length (ulnar variance) as the most crucial radiological parameter that influences the functional outcome [10,19].

AO classification is the most detailed and useful system for classification of distal radial fractures with significant interobserver agreement [20,22]. We selected AO classification to classify fractures in our series based on these observations.

K-wire fixation for unstable fractures of distal radius is a good technique to prevent redisplacement. Removal of wires can be done at any convenient point after the fourth week as practiced widely but preferably before 6 weeks. Loss of reduction after removal of wires is insignificant and is not influenced by age, fracture comminution, and period of fixation.

External fixation has been popular for the treatment of displaced fractures of distal radius, and the radial length and dorsal tilt have improved significantly with this method [15,22,30]. External fixation can be supplemented with percutaneous wires through the radial styloid for certain intra-articular fractures. Combined internal and external fixation is a technique that attempts to maximize the advantageous features of each of its two components while minimizing their disadvantages. Seitz *et al*. reported a 92% satisfactory result in 51 patients treated with augmented external fixation using K-wires to reduce and fix unstable fragments [25]. The external fixator could maintain radial length more efficiently than the percutaneous pinning and casting group, but volar tilt was not generally restored [12]. Pin tract infection is another problem that should be concerned.After closed reduction in our study patients, the fractures were fixated directly with percutaneous K-wires. Because K-wire fixation seldom provides sufficient stability to allow for early motion and often necessitates use of a cast or splint, percutaneous K-wire fixation of the distal radius fractures is one of the simplest and most commonly performed procedures. Pin tract infections following percutaneous K-wire fixation of distal radius fractures forces extended hospital stay of patient, early pin removal, and poor functional outcome secondary to redisplacement and malunion of distal radius fracture, and this occurred in 10 cases, seven of them conservative treatment without effects on final results and three cases needed early removal of K-wires, which lad to displacement and need further operation as they had poor results.

This procedure can be performed for both intra-articular and extra-articular fractures. Green [32] reported an 86% satisfactory result with this technique used in the treatment of 75 patients with severely comminuted intra-articular fractures. The technique is so easy that most surgeons become familiarized with this procedure in a relatively short time. The wires usually can be withdrawn in the outpatient clinic with relative ease when healing is sufficient.

The occurrence of pin tract infection can be controlled successfully after removal of the K-wires and initiation of treatment with oral antibiotics and pin tract care.

Rehabilitation was usually necessary, as wrist stiffness was common immediately following cast and pin removal. However, almost all of the patients could achieve good range of motion of the wrist after a period of physical therapy.

One of the most frequently stated complications associated with most intra-articular fracture is the development of post-traumatic arthritis. In the radiocarpal and distal radioulnar joints, the reported incidence of arthritis was variable.

In this study, the average radial height was 11 mm postoperatively and 10.5 mm after removal of the pin-in-plaster. The average union state of the volar tilt angle was 8.5° compared with 8° in the immediate postreduction state.

Conclusion

In conclusion, percutaneous pinning is an excellent technique for both extra-articular and intra-articular

fractures in cases without severe comminution of the distal radius. The technique involves a minimal procedure that provides anatomic reduction, fracture fixation, and maintenance of reduction with an adequate method of immobilization.

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Conflicts of interest
There are no conflicts of interest.

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