Comparison of Percutaneous K-wire and T-plate Fixation in Treatment of Distal Radius Fractures

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Purpose: *The most effective method for the surgical treatment of distal radius fractures has not been established. Two commonly used techniques are percutaneous K-wire and T-plate fixation. We performed a retrospective study to compare these two treatment strategies.*
Methods: *A total of 68 patients were selected for review. Each patient was treated by one of the two methods. Data including operative time, pain scale, radiological result, disabilities of the arm shoulder and hand (DASH) score, and operative complications were collected.*
Results: *Thirty-six patients were treated with percutaneous K-wire, and the rest (32) were treated with T-plate fixation. The percutaneous K-wire group was associated with significantly shorter operative times and length of hospital stays, and lower postoperative pain (P<0.05), but had more complications (P=0.033). There were no significant differences in DASH scores and radiological results between the two groups.*
Conclusion: *The percutaneous K-wire technique is similar in effectiveness to the T-plate in the treatment of distal radius fractures with shorter operative times and hospital stays, and lower postoperative pain, but had more complications.*

Key words: *Distal radius fractures, T-plate, percutaneous K-wires*

The Thai Journal of Orthopaedic Surgery: 39 No.1-2: 25-33
Full text. e journal: *http://www.rcost.or.th, http://thailand.digitaljournals.org/index.php/JRCOST*

Introduction

Fractures of the distal radius are extremely common. All age groups are affected; younger patients often sustain complicated high energy injuries involving the wrist joint, but fractures of the distal radius are also common in older patients, who are more likely to sustain low energy fractures related to osteoporosis[1].

Fractures of the distal radius are treated non-operatively if the bone fragments can be held in anatomical alignment (reduction) by a plaster cast or orthotic. If this is not possible, surgical fixation is performed. The main factors that determine functional recovery are restoration of normal anatomy and early mobilisation without joint stiffness[2-5]. These goals may be difficult to achieve using nonoperative treatments especially in elderly patients with poor bone quality.

Although a variety of surgical treatments exist for treating distal radial fractures, closed reduction and the insertion of percutaneous Kirschner wires (K-wires) are immensely versatile in fracture fixation, but there are complications such as pin loosening, reduction failure, bone fracture at the site of the pin, and infection[6]. Green has shown acceptable results of pin and plaster treatment in 86% of distal radius intra-articular fractures in 75 patients[7]. However, studies have demonstrated that plaster fixation often cannot preserve reduction and modify the length[8]. In these cases, reduction will normally fail two weeks after plaster reduction[9]. Spira reported unsuccessful results in 42% of intra-articular factures treated with plaster as well[10]. Open reduction and internal fixation (ORIF) has some advantages such as increased stability and rapid return of movement in unstable and intra-articular distal radius fractures. ORIF with locking compression plate (LCP) has good to perfect radiographic and functional results in comminuted intra-articular distal radius fractures and minimizes the number of unacceptable results[11,12]. The complications are surgical trauma, devascularization of segments, wrist stiffness, the need for plate removal, and tendon irritation or rupture. In addition, this invasive method cannot be performed everywhere[13-16]. Open reduction and internal fixations using a variety of dorsal, radial, or volar plates have been reported. However, both dorsal and radially placed plates are associated with significant soft tissue problems including adherence of the overlying soft tissues, tendon irritation, and rupture[17]. Compared with dorsal and radial plates, volar plates are associated with fewer soft tissue complications and have become increasingly

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popular over recent years since the introduction of locking plates[18-25].

The purpose of this study was to retrospectively compare between the two techniques in terms of clinical outcomes. Also, the functional recoveries and operative complications were examined in detail.

Patients and Methods

A retrospective review was conducted between 2007 and 2014, 68 patients with distal radius fractures were surgically treated at Sawangdandin Crown Prince Hospital. Inclusion criteria for this study were (a) patients with an acute, displaced, and unilateral fracture, (b) internal fixation with either a T-plate or percutaneous K-wire fixation, (c) age greater than 18 years, and (d) normal wrist function before injury. Exclusion criteria included (a) pathological fractures, (b) primary or metastatic bone tumours, (c) bilateral fractures, (d) open fractures, (e) ipsilateral limb injuries, and (f) any medical condition that excludes surgical treatment.

The operative technique for each group was as follows: T-plate group, patients with distal radius fractures were treated with open reduction and internal fixation (ORIF) with an AO non-locking volar buttress plate. Surgery was performed under general anesthesia and a tourniquet was used in all cases. The radius was approached via a volar approach through the bed of flexor carpi radialis tendon. After release of the pronator quadratus muscle from its radial insertion, the fracture site and the palmar surface of the distal radius were exposed. Fracture reduction was verified with fluoroscopy and then temporarily stabilised with K-wires. The T-plate was placed on the volar cortex and fixed using the standard technique of screw fixation to allow for appropriate positioning. Depending upon the fracture, fragments were indirectly reduced using a combination of direct pressure and ligamentotaxis before inserting the distal screws. If the fracture site had a bone gap, an iliac bone graft was inserted. When feasible, the pronator quadratus muscle was repaired to protect the flexor tendons. The wound was closed in layers with suction drainage. (Fig. 1, 2) The active range of motion (ROM) exercises were initiated on the first postoperative day. Sutures were removed after 10 days. Follow up was at one week, then every month for 6 months, and then at 12 months for a final evaluation.

Percutaneous K-wire fixation group: the fracture was reduced with traction and direct manipulation under anesthesia. A series of K-wires were then used to maintain the reduction. Typically, at least three K-wires were used to secure the radial styloid to the diaphysis. Intraoperative fluoroscopy was used to confirm adequate reduction and pin position. Most of the K-wires were placed out of the skin. If the fracture site had a bone gap, an iliac bone graft was inserted. A short arm cast was applied for six weeks. (Fig. 3, 4) Postoperatively, finger ROM was encouraged immediately. At six weeks after surgery, all the K-wires were removed. Physiotherapy after cast removal was performed. Strengthening was initiated as ROM improved and symptoms returned to normal.

Fig. 1 Anteroposterior and lateral radiographs of a distal radius fracture of a 32-year-old man.

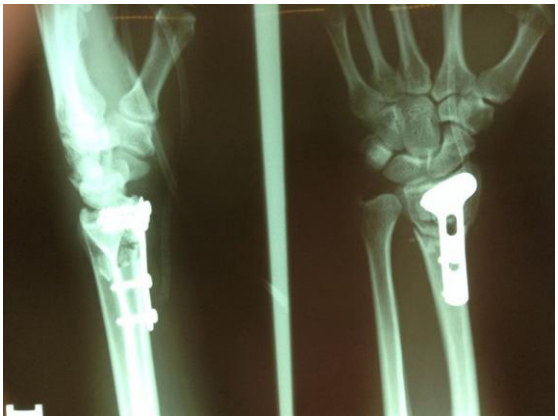

Fig. 2 Radiographs 1 day after surgery

Fig. 3 Anteroposterior and lateral radiographs of a distal radius fracture of a 39-year-old man.

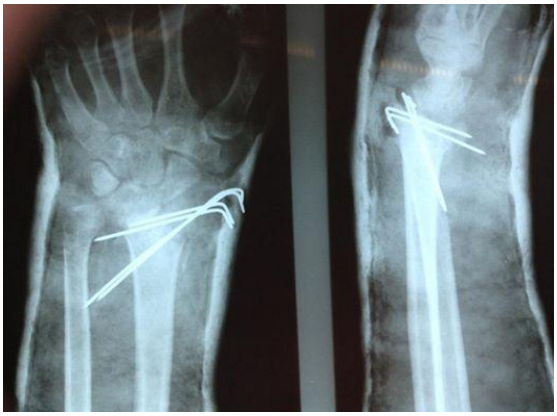

Fig. 4 Radiographs 2 weeks after surgery

Standard anteroposterior and lateral radiographs were taken for radiological evaluation including volar tilt, radial inclination, ulnar variance, and radial height at six months. Fracture reduction was defined as acceptable when volar tilt was 11° ± 5°, radial height was 14 ± 1 mm, radial inclination was 22° ± 3°, and ulnar variance was 0.9 ± 1.4 mm. Radiographic healing was interpreted by the surgeon at each follow-up. Radiographic healing was defined as evidence of bridging callus across the fracture sites or the obliteration of the fracture lines within three months. Patients with incomplete callus bridging four months after surgery were considered to have delayed healing. Patients without radiographic evidence six months after surgery were considered to have fracture nonunion.

The data recorded for all patients included operative time, pain visual analogue scale (0, none to 10, severe) on the first postoperative day, and operative complications.

At the 6 months follow-up, functional outcomes were assessed with the Disabilities of Arm, Shoulder and Hand (DASH) questionnaire. This instrument quantifies disabilities related to the upper extremities. The DASH test includes 30 questions; 21 questions evaluate the ability of doing special functions and 9 questions evaluate the symptoms of patients with musculoskeletal problems of the upper limb. This test has a scale from 0 (no disability) to 100 (maximum disability). The validity, reliability, and internal consistency of the DASH test is high. Its Cronbach's alpha in English and Persian is 98 and 96, respectively[26,27]. Descriptive statistics were compiled for all data points. Chi-square analyses were used to compare categorical variables. Independent samples students *t*-tests were used to compare continuous variables between two groups. Two-sided *P*-values less than 0.05 were considered statistically significant.

Results

There were 68 patients in the present study, with an average age of 47.9 years (range 18 years to 71 years). All were followed up for more than six months after discharge from the hospital. The average follow-up was 12.8 months (range six months to 24 months). The 68 patients were divided into two groups, based on the method of treatment. The T-plate group included 32 patients and the percutaneous K-wire group included 36 patients. The average length of hospital stay was 5.8 days (range 4-7 days) for the T-plate group and 3.5 days (range, 3-4 days) for the percutaneous K-wire group; this difference was significant ($P<0.01$). The mechanisms of injury and demographics data related to each group are shown in Table 1.

Both groups were similar in fracture patterns on AO classification (Table 2). The difference between the two groups was not found to be significant ($P = 0.580$).

Table 1 The injury mechanism, length of hospital stay, and preoperative demographics for both treatment groups

Characteristics	T-plate (n=32)	SD	Percutaneous K-wire (n=36)	SD	*P*-value
Gender (M/F)	17/15		20/16		0.841
Age (years) : mean (sd)	47.6	4.8	48.3	5.1	0.632
Follow-up (months) : mean (sd)	12.7	3.2	12.9	3.3	0.566
Vehicular trauma : number (%)	18 (56.2%)		19 (52.7%)		0.774
Injury time (days) : mean (sd)	1.5	0.3	1.7	0.4	0.687
Length of hospital stay : mean (sd)	5.8	0.5	3.5	0.4	<0.01

Table 2 Characteristics of fractures

Fracture type	T-plate	Percutaneous K-wire
A2	14	15
A3	16	16
C1	2	5
Total	32	36

The mean operative time was 86 minutes (range 61 to 118 minutes) for the T-plate group and 43 minutes (range 31 to 58 minutes) for the percutaneous K-wire group; this difference was significant. The average pain scores on the first postoperative day were 4.8 for the T-plate group and 2.3 for the percutaneous K-wire group; this difference was also significant. The details of outcomes are given in Table 3.

Table 3 Comparison of outcome between the two treatment group

Outcome	T-plate (n=32)	SD	Percutaneous K-wire (n=36)	SD	*P*-value
Operative time (min)	86 (range, 61-118)	15	43 (range, 31-58)	6	<0.01
Pain scale	4.8 (range, 2-8)	1.4	2.3 (range, 1-4)	0.6	<0.01

At the 6 months follow-up, in the T-plate group, the mean DASH score was 24.8 points. In the percutaneous K-wire group, the mean score was 26.3 points. There was no significant difference in the scores between the two groups ($P = 0.221$).

The volar tilt was 10.2° in the T-plate group and 9.8° in the percutaneous K-wire group. The difference between the two groups was not found to be significant ($P = 0.482$). The radial inclination was 21.8° in the T-plate group and 20.2° in the percutaneous K-wire group. This difference between the two groups was not found to be significant ($P = 0.149$). The radial height was 12.3 mm in the T- plate group and 11.8 mm in the percutaneous K-wire group. The difference between the two groups was not found to be significant ($P = 0.383$). The ulna variance was 0.8 mm in the T-plate group and 0.7 mm in the percutaneous K-wire group. The difference between the two groups was not found to be significant ($P = 0.484$) (Table 4).

Table 4 Comparison of shoulder scores and radiological results between the two groups

	T-plate	SD	Percutaneous K-wire	SD	*P*-value
DASH score	24.8 points (11-38)	6.8	26.3 points (14-40)	6.5	0.221
Volar tilt (degree)	10.2 (8-12)	1.1	9.8 (7-12)	1.3	0.482
Radial inclination (degree)	21.8 (18-26)	2.1	20.2 (16-25)	2.2	0.149
Radial height (mm)	12.3 (9-16)	1.8	11.8 (8-15)	1.7	0.383
Ulna variance (mm)	0.8 (-1 to 2.4)	0.9	0.7 (-1.2 to 2.2)	0.8	0.484

Postoperative complications were noted in 5 patients in the T-plate group and in 14 patients in the percutaneous K-wire group. In the T-plate group, there were two patients with superficial infections. No plate failures, screw penetration into the joint, or extensor tendon ruptures were noted. The superficial infections were diagnosed clinically at the first follow-up visit seven days after surgery. After seven days of treatment with oral antibiotics, the wounds healed uneventfully. In the percutaneous K-wire group, there were three patients with superficial infections. Removal of the pins and oral antibiotics resolved the problem. This difference was statistically significant ($P = 0.033$) (Table 5).

Table 5 Comparison of complications in both groups

	T- plate	Percutaneous K-wire
Infection	2	3
Loss of reduction	0	4
Malunion	1	2
Stiffness	2	1
Implant loosening	0	4
Total	5	14

Discussion

Fractured distal radiuses are among the most common injuries treated by orthopaedic, trauma, and hand surgeons[28]. Factors such as fracture types, associated injuries, bone quality, and general health of the patients should be considered when choosing treatments. We know that the most important factors that influence long-term results are early mobilisation and restoration of normal anatomy[2]. In our study, maintenance of reduction was better in the T-plate group compared with the percutaneous K-wire group, but this difference did not reach statistical significance. In addition to restoring anatomy, the other real advantage of using T-plates was improved fracture stability. Our experience showed the subchondral bone of the distal radius could be adequately maintained by the fixed screws.

In a study by Huard et al[29], a volar non-locking plate or K-wires was used for the treatment of 38 distal radial fractures in patients over 70 years old. Twenty-one fractures were treated by volar plating and 17 by percutaneous K-wire fixation. They found that secondary displacements were frequent in both groups (37% of the plate group versus 50% of the K-wire group). Voigt and Lill[30] reported that 89 distal radius fractures in the elderly were treated by a volar non-locking plate ($n = 46$) or K-wire-fixation ($n = 43$). They found that loss of reduction was frequent in both groups and did not differ significantly between the groups. They thought that non-locking volar plating or K-wiring for the treatment of distal radius fractures in the elderly with poor bone quality might have a risk of secondary displacement. In our study, four fractures (11.1%) had a loss of reduction in the percutaneous K-wire group. We thought that the better radiological results in the T-plate group might be due to the higher rigidity of the fixation. The mean age in our study is slightly younger than the typical radius fracture population. Younger patients with better bone quality might benefit more from an open reduction and internal fixation than the osteoporotic elder.

In our study, the T-plate group had a low complication rate. There were no cases related to skin necrosis or delayed wound healing. We thought that a short injury–surgery interval might be an important factor. Theoretically, early skeletal stabilisation could reduce progression of soft tissue damage and might decrease skin problems. In addition, the fracture reduction and screw insertion was verified with fluoroscopy in all cases. This procedure avoids screw penetration into the joint or damage to the extensor tendons. Breakage of the plate was not reported and those cases of screw loosening originated from bone/fracture or surgical technique problems, rather than the implant itself. In some severe intra-articular fractures, it was necessary to place the plate distally from the watershed line[31], which is a transverse ridge that closes the concave surface of the volar radius distally. If the plate is placed above or distally from this line, it increases the risk of flexor tendon rupture. Column-specific fixation of the distal radius seems essential to achieve satisfactory results in complex intra-articular fractures[32]. Some advocate the use of plates to reach this goal[33]. We believe, however, that this column specific stabilisation can be done adequately using ligamentotaxis and simple 2.7 mm AO plates to maintain reduction. We recommend placing the implant up to and not beyond the watershed line as a necessary step to avoid contact and injury to the flexor tendons.

In our study, for smaller patients treated for a type-C distal radial fracture in the T-plate group, we describe good anatomical results and functional stability, enabling immediate range of motion and quick return to daily activities. In many articles there is a large heterogeneity in fracture types. This will confound and flatter the results. The improvement in ulnar variance was an important outcome indicator[34].

Intrafocal manipulation provides a sufficient realignment and a good contact at the fracture surface while avoiding overtraction of the fracture site and undue stress concentrations in the implant[35]. Cross-pin transfocal fixation provides a great resistance to gross rotational displacement and prevents the intrafocal-pin related complications such as implant impingement pain, stiffness, CRPS, infection, loosening, or nonunion[36]. Our study showed that early fracture collapse occurred in patients with a displaced extra-articular distal radius fracture treated by percutaneous pinning and early mobilization. However, the final radiographic results of the two methods which we studied were both described as acceptable in terms of the radiographic measurements according to the criteria of Graham[37].

In our study, radiographic results were not significantly better in the T- plate group. In Kwan's study 96-98% of patients had good to perfect results[38]. In addition to volar tilt, radial inclination, and radial height, articular congruence is an important factor in the long-term outcomes of fractures of the distal radius. Residual dorsal angulation leads to increased torque and changes in load bearing across the radiocarpal and ulnocarpal joints[39]. Changes in the normal volar tilt of the distal radius leads to a shift in contact points for load transfer and a significant increase in the axial load supported by the ulna and ulnocarpal joint of greater than 200%[40]. An increase or decrease in ulnar variance of as little as 1 mm can alter the biomechanics of the wrist as well. Residual ulnar-minus deformity can lead to scapholunate dissociation and excess ulnar-positive deformity which can cause ulnocarpal impaction. Loss of radial height is associated with shifts in the center of rotation during pronation and supination, as well as an increased strain on the triangular fibrocartilage complex of up to 13%[41]. Up to 20° of dorsal angulation and a minimum of 10° of radial inclination have been shown to have acceptable functional results[42]. Ulnar variance and radial height are less forgiving, with functional outcomes affected by only a few millimeters of change. Among the radiographic measurements, the volar tilt was the most difficult to achieve and to maintain when repositioning and pinning the fractured fragments and realigning the radial geometry. Normal volar tilt should average about 11 degrees[43]. The two techniques we used in this study were reliable in restoring the long term normal volar tilt even in the presence of conventionally acceptable radiographic results. It

seems that radial length is the most important radiologic and anatomic parameter that defines the clinical outcome[44] and it seems that any technique that maintains the radial length may end in a better functional result[45].

One of the most frequent complications associated with most intra-articular fractures is the development of posttraumatic arthritis. In terms of an articular congruence, 2 mm of step off is significant for the development of radiographic signs of posttraumatic arthritis. In the radio-carpal and distal radio-ulnar joints, the reported incidence of arthritis was variable. Knirk and Jupiter[46] noted that all patients who had an articular step off of greater than 2 mm at the time of union developed radiographic evidence of posttraumatic arthritis. Only 11% of patients who had normal articular congruence at the time of union developed radiographic evidence of posttraumatic arthritis regardless of the amount of articular displacement at the time of injury. The development of radiographic evidence of posttraumatic arthritis has not been shown to affect functional outcomes[47] and symptomatic complaints[48]. There was no incidence of posttraumatic arthritis reported in our patient population because long-term follow-ups were not available.

There was no significant difference in the disabilities of arm, shoulder and hand (DASH) at 6 months in the two groups, but this was well below the minimum clinically important difference[49]. Kirschner-wire fixation requires significantly shorter surgical operating times than T-plate fixation and a reduced use of perioperative antibiotics.

This study had a few limitations: (a) it was a retrospective study and not randomised, so there was selection bias, (b) the size of the study was relatively small, thus a few comparisons lacked statistical power, and (c) the follow-up period of one year may be too short to draw final conclusions on long-term outcomes and complications.

Conclusion

Both T-plate and percutaneous K-wire for the treatment of distal radius fractures could achieve good results. However, percutaneous K-wire fixation had more advantages, such as shorter operative times and hospital stays, and lower postoperative pain, but had more complications than T-plate fixation.

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การศึกษาเปรียบเทียบระหว่าง percutaneous K-wire และ T-plate ในการรักษาผู้ป่วยที่มีกระดูกเรเดียสส่วนปลายหัก

สมบูรณ์ วุฒิพิริยะอังกูร, พบ

วัตถุประสงค์: *เพื่อศึกษาเปรียบเทียบผลการรักษาระหว่าง percutaneous K-wire และ T-plate ในการรักษาผู้ป่วยที่มีกระดูกเรเดียสส่วนปลายหัก*

วิธีการ: *การศึกษาวิจัยแบบย้อนหลังโดยดูระยะเวลาในการผ่าตัด ระดับความเจ็บปวดหลังการผ่าตัด DASH score ผลทางรังสีวิทยา และข้อแทรกซ้อน*

ผลการรักษา: *ผู้ป่วย 68 ราย แบ่งเป็น 2 กลุ่ม ได้แก่ กลุ่ม percutaneous K-wire จำนวน 36 ราย และกลุ่ม T-plate จำนวน 32 ราย ผลการรักษาไม่แตกต่างกันอย่างมีนัยสำคัญใน DASH score และ ผลทางรังสีวิทยา แต่กลุ่ม percutaneous K-wire ใช้ระยะเวลาในการผ่าตัดน้อยกว่า ระยะเวลานอนโรงพยาบาลน้อยกว่า และมีระดับความเจ็บปวดหลังการผ่าตัดน้อยกว่าอย่างมีนัยสำคัญ ($P < 0.05$) แต่มีข้อแทรกซ้อนมากกว่า ($P = 0.033$)*

สรุป: *การผ่าตัด percutaneous K-wire มีคุณภาพเท่ากับ T-plate ในการรักษาผู้ป่วยที่มีกระดูกเรเดียสส่วนปลายหัก โดยใช้ระยะเวลาในการผ่าตัดน้อยกว่า ระยะเวลานอนโรงพยาบาลน้อยกว่า และมีความเจ็บปวดหลังผ่าตัดน้อยกว่า แต่มีข้อแทรกซ้อนมากกว่า*