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ORIGINAL STUDY

Percutaneous K-wire fixation versus palmar plating with locking screws for Colles' fractures

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Different methods exist to treat distal radius fractures. A prospective randomized study was conducted to establish whether palmar plate fixation with locking screws gave better results than percutaneous K-wire fixation in patients over 50 years of age. Only fractures with dorsal displacement after a simple fall were included in the study. Twenty wrists were treated with K-wires and 20 with a plate. Radiological parameters were measured on preoperative radiographs and at five weeks postoperatively. Clinical results and DASH scores were determined at three months postoperatively and at more than one year. No significant difference in radial inclination, palmar tilt, clinical outcome and DASH score was found between plating and K-wires, but the mean difference in ulnar variance between pre- and postoperative radiographs was significantly better with plates. It can be concluded that plates were superior to K-wires in restoring ulnar variance, but functional outcome was similar with both techniques.

Keywords :

INTRODUCTION

Distal radius fractures are more common in postmenopausal women and are usually the result of a fall from standing height (*23*). Lifetime risk of a wrist fracture at the age of 50 years is four to six times higher in women than in men (*13,22,32*). The optimal management for displaced distal radius fractures has not yet been established (*9,18*). Although the association between radiological and functional outcome is controversial, restoration of normal anatomy has been recommended in active patients (*6*). Radial length is a radiological parameter that has been shown to correlate with functional outcome. It should be measured at the level of the distal radioulnar joint and compared with the contralateral wrist (*11,21,31,34*). To prevent loss of reduction following manipulation and casting, additional fixation can be done with devices such as plates (*2*), K-wires (*26*), external fixators (*28*) or intramedullary nails (*3*). Initially, palmar plates were used to treat palmarly displaced fractures (*5*) and K-wires to treat Colles' fractures (*30*). K-wire fixation is minimally invasive and inexpensive, but it may be difficult to maintain radial length in patients with osteoporotic bone (*25*). Since the introduction of plates with lock-

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ing screws, palmar plating has become popular to stabilize distal radius fractures with dorsal displacement (*16*). Anatomy can be restored and maintained, even in elderly patients with osteoporosis (*7,24*). Another advantage is that mobilization of the wrist can be started early, resulting in a faster functional recovery than with other treatment methods (*27,35*). Although the palmar surface of the distal radius is more suitable for plate fixation than the dorsal surface, palmar plates can cause tendon problems and a second operation may be required to remove the implant (*1*).

The purpose of the present study was to investigate the differences in radiological and functional outcome between palmar plates with locking screws and percutaneous K-wire fixation in patients over 50 years of age with Colles' fractures.

PATIENTS AND METHODS

Study design

A prospective randomized study was conducted at the Ghent University Hospital Department of Orthopaedic Surgery and Traumatology. The study was approved by the hospital's ethics committee and all patients gave informed consent prior to starting the study.

Patient selection

The inclusion criteria for the present study were men and women at least 50 years old who had sustained a dorsally displaced fracture of the distal radius following a simple fall. Distal radius fractures with an associated fracture of the ulnar head were excluded, as were patients who had previously sustained a fracture of the distal radius and patients with bilateral fractures or mental disorders. Fractures sustained from high-energy trauma such as traffic accidents or falls from heights were excluded also. The orthopaedic surgeon at the emergency department asked the patients if they agreed to participate in the study after they had been properly informed.

Randomization

Whether the fracture would be stabilized with a plate or K-wires depended on a list generated by the first author. A computer program (Microsoft Office Excel) had been used to randomize the procedures. The sequence was not concealed. Patients were enrolled and were assigned to the respective groups by the first author.

Treatment

Patients were operated on by surgeons of our department, including the authors of the present study. Orthopaedic surgeons in training were supervised by senior surgeons. All surgical procedures were performed under general anaesthesia with use of a tourniquet. In case of K-wire fixation, the fracture was reduced under fluoroscopic guidance. Two or three K-wires, 1.6 mm in diameter, were used to stabilize the fracture. In eight patients, all K-wires were introduced intrafocally according to the method of Kapandji (*14*). In 12 wrists, the radial K-wire was inserted through the radial styloid process and the dorsal K-wires intrafocally. The K-wires were left outside the skin to facilitate their removal at five weeks postoperatively. In case of palmar plate fixation, after closed reduction and manipulation, the fracture was temporarily stabilized with two percutaneous K-wires. The Henry approach to the distal radius was used and a 2.4-mm LCP distal radius plate with locking screws was inserted (Synthes). The K-wires were removed once the fracture was stabilized with the plate. The skin was closed with separate nonabsorbable sutures. In both groups, a forearm plaster cast was applied for five weeks. The duration of the surgical procedures was noted.

Radiographic measurements

Radiological parameters (ulnar variance, palmar tilt, radial inclination) were determined on preoperative radiographs and at five weeks postoperatively. The difference in ulnar variance between the fractured and contralateral wrist was measured. Intra-articular incongruity (2-mm steps or larger) and anterior displacement of the distal fracture fragment were also noted. Parameters were measured on digitized radiographs in the hospital's PACS system by the first author according to the method described by Kreder (*17*). Radiographs of a wrist fracture treated with a palmar plate and locking screws are shown in Fig. 1 and a wrist treated with K-wires in Fig 2.

Clinical outcomes

Functional outcome was determined using the Dutch version of the disability of arm shoulder and hand score

Fig. 1. — Distal radius fracture treated with a plate in a 66-year-old woman.
A & B : preoperative radiographs ; C & D : 5 weeks post-operatively.

Fig. 2. — Distal radius fracture in a 57-year-old woman treated with percutaneous K-wires. A & B : preoperative radiographs. C & D : radiographs 5 weeks postoperatively.

(DASH) (*19*). Clinical examination included measurement of grip strength and range of motion of both wrists. Grip strength was measured with a Jamar dynamometer (Camp Ltd. NJ, USA). Range of flexion and extension, pronation and supination, and radial and ulnar deviation were measured with a goniometer. These measurements were performed at three months and at more than one year postoperatively (mean 19 months, range : 12-26 months). Range of motion and grip strength of the fractured wrist were expressed as a percentage of the contralateral uninjured wrist (*31*). The first two authors performed the clinical examination and obtained the DASH score. Complications were also noted in both groups.

Study blinding

Blinding was not possible, because of the surgical scars and on the radiographs the type of treatment was visible.

Sample size

The hypothesis of the study was that correction of ulnar variance is important to achieve a good functional outcome when treating distal radius fractures, and that plates may be better suited to do this than K-wires. Difference in ulnar variance was used to perform *a priori* power analysis. A meaningful difference was

estimated to be 2 mm (*6*). A mean increase in ulnar variance of 3 mm with a standard deviation of 2 mm was found in patients over 59 years of age treated with K-wire fixation (*12*). We estimated that at least 17 patients in each group were needed to find a significant difference in ulnar variance of 2 mm between plates and K-wires, with 80% power.

Statistical methods

Statistical analysis was performed with SPSS software. The Mann-Whitney U test was used to determine if the outcome was significantly different between the two surgical techniques.

Significance was set at $p < 0.05$.

RESULTS

Patient cohort

Between September 2006 and February 2008, a total of 83 patients over 50 years of age were operated on for a displaced distal radius fracture. In 35 patients inclusion criteria were not met (eight had an associated fracture of the ulnar head, three had mental disorders, seven fractures were not dorsally displaced, six patients already had sustained a distal radius fracture, nine had a high-velocity trauma, and two had bilateral fractures). Six patients declined. Two patients were enrolled but excluded afterwards because a combination of a plate with a K-wire had been used in one of them and additional bone grafts in the other.

Mean age of patients treated with K-wires was 66 and with a plate 67 years. Four men and 36 women were included in the study. All men were treated with a plate. Twenty-two fractures were intra-articular ; 13 of these were stabilized with K-wires and nine with a plate. Seven patients were employed, 14 were housewives and 19 retired. The two treatment methods were equally distributed among these three groups. The dominant hand was fractured in six patients treated with K-wires and in nine treated with a plate. Surgery took longer for fractures stabilized with a plate. Mean operating time for plates was 65 minutes (SD : 20) and for K-wires 32 minutes (SD : 14). The difference was significant ($p < 0.001$).

A number of patients were lost to follow-up. A schematic representation is given in the flow diagram (Fig. 3). In the K-wire fixation group, one patient failed to present for the three months' follow up. At 12 months, two patients were lost to follow-up, one because of mental disorders and the other could not be reached anymore. Three patients chose not to come to the hospital for clinical examination and the DASH score was the only outcome measure that could be obtained by telephone. The plate fixation group contained one patient with rheumatoid arthritis whose condition had become worse at the time of follow-up, so that the DASH score and clinical outcome were not determined. The patient was contacted and the plate was still in place. One patient was lost to follow-up because she was not satisfied. She had symptoms of complex regional pain syndrome (CRPS) and went to another hospital where the plate was removed. Two other patients in whom the fracture was treated with a plate, failed to present for evaluation at three months, but did so at 12 months. At 12 months one patient was lost to follow-up because she had died. Her plate had not been removed. Another patient could not be reached anymore. In one low-demand patient, the DASH score could not be determined at three and 12 months because she did not perform enough activities. In another patient, the DASH score could not be calculated at three months because he had sustained a fracture of the humeral head. The fracture healed and at 12 months the DASH score could be obtained.

Radiographic outcomes

The results relating to the radiological parameters are presented in table I. Mean values for palmar tilt, radial inclination and ulnar variance did not differ significantly between K-wires and palmar plates on preoperative radiographs and on radiographs taken at five weeks postsurgery. When the difference between pre- and postoperative radiographs was measured, mean correction in ulnar variance in the K-wire and in the plate group was 0 mm and -2 mm, respectively. This difference was statistically significant. In the plate group, three patients had intra-articular steps or gaps of 2 mm or

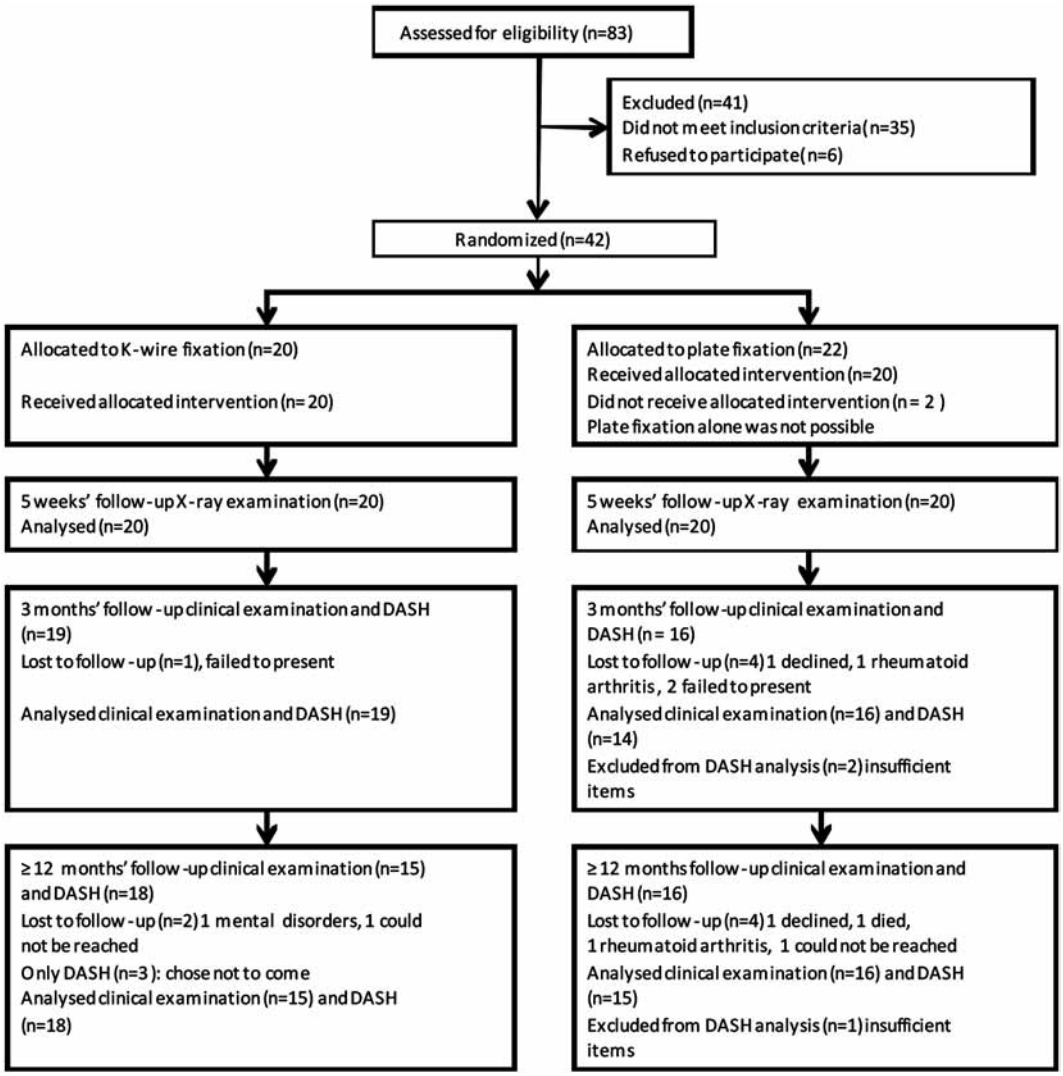

Fig. 3

Table I. — Outcome of radiographic parameters. (SD : standard deviation)

Radiographic parameters	K-wire (SD)	Plate (SD)	P
Mean radial inclination (preop) :	18° (18)	18° (18)	0.76
Mean palmar tilt (preop) :	-21° (10)	-20° (13)	0.46
Mean increase in ulnar variance (preop) :	2 mm (2)	3 mm (3)	0.50
Mean radial inclination (5 weeks postop) :	22° (7)	25° (5)	0.46
Mean palmar tilt (5 weeks postop) :	3° (12)	2° (9)	0.36
Mean increase in ulnar variance (5 wks postop) :	2 mm (2)	1 mm (2)	0.20
Mean correction radial inclination :	4° (6)	7° (6)	0.21
Mean correction palmar tilt :	24° (17)	21° (19)	0.53
Mean correction ulnar variance :	0 mm (2)	-2 mm (3)	0.04*

Table II. — Results of clinical examination and DASH score. Range of motion is expressed as a percentage of the contralateral wrist

	K-wires (SD)	Plate (SD)	P
Mean flexion extension range (3 months) :	73 % (17)	74 % (15)	0.95
Mean pronation supination range (3 months) :	89 % (11)	89 % (15)	0.40
Mean radioulnar deviation range (3 months) :	68 % (22)	74 % (16)	0.20
Mean grip strength (3 months) :	56 % (31)	60 % (30)	0.83
Mean DASH score (3 months) :	27 (24)	21 (21)	0.90
Mean flexion extension range (≥ 1 year) :	86% (15)	90% (8)	0.63
Mean pronation supination range (≥ 1 year) :	98% (6)	97% (8)	0.35
Mean radioulnar deviation range (≥ 1 year) :	89% (18)	90% (17)	0.98
Mean grip strength (≥ 1 year) :	94% (40)	82% (30)	0.34
Mean DASH score (≥ 1 year) :	13 (20)	14 (16)	0.55

Table III. — Complications (CRPS : complex regional pain syndrome ; EPL : extensor pollicis longus)

	K-wires	Plate
Superficial infection	2	0
Deep infection	1	1
CRPS	2	1
Carpal tunnel syndrome	2	1
Trigger finger	2	0
Additional surgery to remove hardware	1	3
EPL rupture	1	0

larger. Loss of reduction with recurrence of more than 9° of dorsal tilt occurred in two patients treated with a plate and in five with K-wires. Loss of reduction with palmar displacement did not occur following fixation with a palmar plate, but was present in three wrists treated with K-wires.

Clinical results

The results are shown in table II. No significant differences were found in clinical outcome and DASH score at three months and at more than 12 months postoperatively.

Complications

Complications were seen in both groups (Table III). In three wrists treated with K-wires, a pin tract infection occurred, which was superficial in two patients and healed after removal of the K-wires. In the third patient, a surgical procedure was needed to treat the infection. In one patient treated with a plate, a surgical intervention under general anaesthesia was required to treat a deep wound infection. The infection healed without the need to remove the implant. In three patients, the palmar plate was removed because of pain. One K-wire had to be removed under local anaesthesia because it was subcutaneously located. Other complications were CRPS, trigger finger, carpal tunnel syndrome and rupture of the extensor pollicus longus tendon. No surgical procedures were needed to treat these problems.

DISCUSSION

Our study demonstrated that palmar plates with locking screws were superior to K-wires for the correction of ulnar variance when treating dorsally displaced distal radius fractures in patients over 50 years of age. Similar conclusions were reported in a prospective study comparing intrafocal K-wire fixation with a palmar fixed-angle plate in patients over 60 years of age (*25*). In a prospective randomized study, comparing mixed pinning with a palmar fixed-angle plate in patients over 50 years of age, no significant difference in ulnar variance between plates and K-wires was found, but loss of ulnar variance was greater with K-wires. The difference in ulnar variance was measured on radiographs immediately postoperatively and at 26 weeks.

Palmar tilt was found to be better restored with K-wires, but this may have been due to palmar over-correction, as 15% of wrists treated with pinning had a palmar tilt of more than 15° (*20*). In our study, a similar percentage of wrists with palmar displacement following treatment with K-wires was found. In a prospective randomized trial including young and old patients, no difference in radiographic outcomes was found between a palmar plate with locking screws and crossed K-wire fixation, but ulnar variance had not been measured (*27*).

The method of K-wire fixation may influence the radiological outcome in elderly patients. Intrafocal pinning was not effective for correcting ulnar variance (*25*) and palmar displacement was more frequent with intrafocal (*12*) than with mixed pinning (*20*). In a retrospective study in which two K-wires were introduced from the radial styloid process, mean loss in ulnar variance was not greater with K-wires than with a palmar fixed-angle plate (*33*). However, in another study of extrafocal K-wire fixation, radial shortening could not be corrected (*15*).

In our study, no difference in clinical outcome could be found between plates and K-wires despite a better correction of ulnar variance. The mean difference in ulnar variance between the two groups in comparison with the uninjured wrist was only 1 mm, which may not be sufficient to find a significant difference in functional outcome. Another reason is that our study also included elderly low-demand patients, in whom there is less or no correlation between results and function (*8,11*). However, in another study, significantly better flexion, supination, grip, DASH and Herzberg scores were found in elderly patients with plates, compared to mixed pinning (*20*). Oshige *et al* also found better flexion and grip strength in patients treated with a plate, but not all patients had a follow-up of more than one year (range between six and 30 months) (*25*). In the study of Rozenthal *et al*, functional results were better in the early post-operative period but not at one year (*27*).

A disadvantage of percutaneous K-wire fixation is the possibility of pin tract infection (*10*). We had three cases of infection with K-wires (15%) and one with a plate. In the study of Marcheix *et al*, six percent of wrists treated with K-wires had an infection and none of the wrists treated with a plate (*20*). As discussed previously, another disadvantage of K-wire fixation is a greater loss of reduction compared with palmar plates. However, this may not be a problem in elderly patients, in whom the correlation between anatomical results and outcome is less pronounced (*8,11*). In active patients, the use of a palmar plate may be a better option than K-wires, as return to function was faster with plates (*27*).

A disadvantage of palmar plating with locking screws is the high cost compared to K-wire fixation (*29*), and the longer duration of surgery (*20*). Moreover, a second operation may be required for plate removal. We had to remove the implant in three patients (15%). In the literature, percentages of plate removal range between 0% (*24*) and 17.5% (*1*). In one study removal of all plates after 4 months was advised to prevent tendon ruptures (*4*).

Although anatomical restoration may be superior with palmar fixed-angle plates than with percutaneous K-wires, it may not be justifiable to treat all dorsally displaced distal radius fractures with a palmar plate with locking screws because surgery takes longer and costs are higher. The results of the present study demonstrated that both percutaneous K-wires and palmar plates with locking screws can be effective to treat Colles' fractures in patients over 50 years of age.

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