A comparative study of Colles' fractures in patients between fifty and seventy years of age: percutaneous K-wiring versus volar locking plating

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Abstract

Purpose This retrospective study was to compare the clinical outcomes of volar locking plating (VLP) and percutaneous Kirschner wiring (PKW) for the management of displaced Colles type distal radius fractures in patients between 50 and 70 years old.

Methods There were 31 elderly patients with displaced Colles' fractures treated by VLP. We compared them to 31 match-paired patients treated by PKW. The patients were matched according to age (within five years) and sex. All patients were followed up retrospectively for at least 12 months. The functional outcomes and radiological results were compared between the two groups.

Results All fractures healed within three months. There were two complications (6.5%) in the PKW group and one complication (3.2%) in the VLP group. At final follow-up, wrist flexion, extension, and ulnar deviation were significantly better in the VLP group compared with the PKW group (all p values < 0.05). According to modified Green and O'Brien criteria, the VLP group showed a trend towards increased rate of satisfactory outcome compared with the PKW group ($p = 0.09$).

Conclusion For the treatment of displaced Colles' fractures in patients between 50 and 70 years old, both groups had high union rate and low complication rate. However, better functional results can be expected in association with open reduction and volar locking plating.

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Introduction

Colles' fractures (distal radius fractures with dorsal angulations) are a serious medical problem. The incidence of these injuries is expected to increase with an aging population [1]. The main factors that determine functional recovery are restoration of normal anatomy and early mobilisation without joint stiffness [4, 11, 17, 19]. These goals may be difficult to achieve using nonoperative treatments especially in elderly patients with poor bone quality [19].

Although a variety of surgical treatments exist for treating distal radial fractures, closed reduction and the insertion of percutaneous Kirschner wires to help maintain fracture reduction is still the popular method. Unfortunately, Kirschner wires may fail to maintain fracture position in elderly patients and are also associated with a high incidence of pin site infection [18]. Open reduction and internal fixation 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 [7]. Compared with dorsal and radial plates, volar plates are associated with fewer soft tissue complications and have become increasingly popular over recent years since the introduction of locking plates [3, 5, 8, 12–16]. There have been a few reports comparing percutaneous Kirschner wiring (PKW) and volar locking plating (VLP) for Colles' fracture treatment [8–10, 21]. The specific aim of this retrospective study was to compare the clinical outcomes of PKW and VLP for the management of displaced Colles-type distal radius fractures in patients between 50 and 70 years old.

Patients and methods

Between January 2007 and May 2010, 291 patients were surgically treated in two orthopaedic departments for distal radial fractures. Inclusion criteria for this study were (a) acute and displaced fractures, (b) all patients between 50 and 70 years, and (c) dorsal-angulated fractures (Colles' fractures). Exclusion criteria for this study were (a) previous fractures or nonunions of the wrist, (b) bilateral fractures, (c) open fractures, (d) severe systemic disease with the American Society of Anaesthesiologists (ASA) Physical Status grade 3 or more, (e) volar-angulated fractures (Smith fractures), (f) ipsilateral limb injuries, and (g) patients who needed help with daily living activities or who were living in nursing homes. There were 31 patients who met the inclusion criteria and were treated by VLP. We compared it to 31 match-paired patients treated by PKW. The patients were matched according to age (within five years) and sex. The type of fracture was classified according to the AO classification. All patients were followed-up for at least 12 months after discharge from the hospital. The injury mechanism and medical condition of each patient were recorded in detail during a retrospective chart review (Table 1).

VLP protocol

A tourniquet was used in all cases. The radius was approached via a volar approach through the bed of flexor carpi radialis tendon. In some cases, the carpal tunnel was opened to improve the exposure of the fracture. 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 fixed-angle 2.7-mm titanium locking plate was placed on the volar cortex and fixed using the standard

Table 1 The injury mechanism, fracture patterns, and medical conditions in the two groups

Patient characteristics	VLP	PKW	<i>P</i> value
Injury mechanism			
Simple fall	20 (64.5%)	23 (74.2%)	0.29
Vehicular trauma	7 (22.6%)	6 (19.4%)	0.5
Other trauma	4 (12.9%)	2 (6.5%)	0.34
Injury–surgery interval			
<4 hours	19 (61.3%)	21 (67.7%)	0.4
4–8 hours	9 (29.0%)	8 (25.8%)	0.5
>8 hours	3 (9.7%)	2 (6.5%)	0.5
AO fracture classification			
A2	5 (16.1%)	8 (25.8%)	0.27
A3	12 (38.7%)	16 (51.6%)	0.22
C1	3 (9.7%)	1 (3.2%)	0.31
C2	8 (25.8%)	4 (12.9%)	0.17
C3	3 (9.7%)	2 (6.5%)	0.5
Medical conditions			
Diabetes	3 (9.7%)	2 (6.5%)	0.5
Liver disease	1 (3.2%)	0	0.5
Renal disease	0	1 (3.2%)	0.5
Alcoholism	0	1 (3.2%)	0.5
Heavy smoker	1 (3.2%)	2 (6.5%)	0.5
Average follow-up (months)	19.2±7.1	15.2±10.8	0.21

VLP volar locking plating, *PKW* percutaneous Kirschner wiring

technique of screw fixation at gliding hole 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. The distal interlocking screws were placed under the image intensifier control subchondrally. When feasible, the pronator quadratus muscle was repaired to protect the flexor tendons. Postoperatively, the injured wrist was immobilised in a below-elbow splint or cast for approximately two weeks. Professional physiotherapy after cast removal was carried out routinely.

PKW protocol

The fracture was reduced with traction and direct manipulation under anaesthesia. A series of K-wires were then used to maintain the reduction. Typically, at least three 0.62 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 under the skin. A below-elbow cast was applied for four to six weeks. Postoperatively, finger ROM was encouraged immediately. At eight to ten weeks after surgery, all the K-wires were removed under local anaes-

thetia. Professional physiotherapy after cast removal was performed. Strengthening was initiated as ROM improved and symptoms returned to normal.

Standard anteroposterior and lateral radiographs were taken for radiological evaluation including dorsal tilt, radial inclination, and radial shortening at two, four, eight, 12 weeks and at final follow-up. The dorsal tilt was expressed as the number of degrees from the neutral position. Fracture reduction was defined as acceptable when dorsal tilt was less than ten degrees, radial shortening was not more than two millimetres and articular incongruity was not more than one millimetre. Radiographic healing was interpreted by the attending surgeon at each follow-up and was verified by the first author of this study. 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 functional result was assessed by the first author. Functional assessment included measurement of active range of wrist flexion, extension, supination, and pronation using a goniometer. Grip power was measured with a dynamometer. At the last follow-up, we evaluated the subjective and objective data by using the modified Green and O'Brien score [6]. An overall score of 90–100 points ranked as excellent, 80–89 points as good, 65–79 points as fair, and <65 points as poor results. We defined excellent and good results as a satisfactory outcome. Fair and poor results were considered an unsatisfactory outcome. Sports activities of patients were recorded; especially involving the upper extremities, including swimming, golf, gymnastics, bowling, and table tennis.

Statistics

Categorical data were analysed with chi-square test with Yates' correction. Comparison of the two treatment groups was performed by analysing the mean values using a paired test for match-paired analysis. SPSS 10.0 statistical software package was used to analyse the data; *p* values below 0.05 were considered to be significant.

Results

Both groups were similar in injury mechanism, injury-surgery interval, fracture patterns, and confounding medical condition (all *p* values >0.05) (Table 1). The operative time was significantly less in the PKW group when compared to the VLP group (25 ± 5.9 versus 56 ± 9.3 , $p < 0.001$). There was no difference ($p = 0.31$) in hospital stay between the

PKW group (2.7 ± 1.4 days, range 1–5 days) and the VLP group (3.3 ± 1.3 days, range 1–7 days). In the PKW group, all fractures healed in three months. The mean healing time was 9.4 ± 3.2 weeks. In the VLP group, healing occurred in all cases in three months with a mean of 10.1 ± 2.3 weeks (Fig. 1). The union rate and healing time was not significantly different between the two groups ($p = 1.0$ and 0.55, respectively).

In the VLP group, there was only one complication (3.2%) and it was related to superficial infection. No plate failures, screw penetration into joint, or extensor tendon ruptures were noted. The superficial infection was diagnosed clinically at the first follow-up visit seven days after surgery. After seven days of treatment with oral antibiotics, the wound healed uneventfully. In the PKW group, there were two complications (6.5%) and both of them related to pin site irritation or infection. Removal of the pins with/without oral antibiotics resolved the problem.

In the VLP group, satisfactory reduction was achieved intraoperatively in all fractures. Two fractures (6.5%) had loss of reduction at final follow-up. No statistically significant

Fig. 1 A 66-year-old male patient who had right displaced Colles' fracture was treated with a volar locking plate. **a** Preoperative anteroposterior and lateral radiographs showed an AO type-A3 fracture. **b** X-rays at two months showed fracture healing with good restoration of the fracture alignment

Table 2 Mean radiological results at final follow-up for both groups

Measurement	VLP	PKW	<i>P</i> value
Dorsal tilt (degree)	0.2±0.1	9.1±4.4	<0.001
Radial inclination (degree)	22.0±3.7	14.4±7.6	0.04
Radial shortening (mm)	0.5±0.9	2.0±1.7	<0.001

VLP volar locking plating, PKW percutaneous Kirschner wiring

difference in loss of reduction was found between initial postoperative reduction and final follow-up ($p=0.49$). In the PKW group, two fractures (6.5%) had no primary reduction intraoperatively. Fifteen fractures (48.4%) had loss of reduction at final follow-up. There was a statistically significant difference in loss of reduction between initial postoperative reduction and final follow-up ($p<0.001$).

At final follow-up, dorsal tilt, radial inclination, and radial shortening were significantly better in the VLP group compared with the PKW group (all p values<0.05) (Table 2). The mean of active ranges of motion and grip strength at final follow-up for the two groups are shown in Table 3. There was no significant difference between the two groups for the grip strength (p values >0.05). However, flexion, extension, and ulnar deviation were significantly better in the VLP group compared with the PKW group (all p values<0.05). According to modified Green and O'Brien criteria, the mean score was 89.0±7.2 points (range 65–100) for the VLP group and 83.2±9.7 points (range 50–100) for the PKW groups. Satisfactory outcome was achieved in 28 fractures (90.3%) for the VLP group. Satisfactory outcome was achieved in 23 fractures (74.2%) for the PKW group (Fig. 2). The VLP group showed a trend of increased rate of satisfactory outcome compared with the PKW group, although this was not statistically significant ($p=0.09$).

In the PKW group, ten patients (32.3%) returned to their previous work three months postoperatively. Eleven patients (35.5%) could do the same exercises six months postoperatively. All the patients needed to have the hardware removed. In the VLP group, 22 patients (71.0%) returned to their previous work three months postopera-

tively. Twenty-four patients (77.4%) could do the same exercises six months postoperatively. Two of 31 patients (6.5%) asked to have the hardware removed. There was a significant difference in return to work and exercise between the PKW group and VLP group ($p=0.002$, $p=0.001$, respectively). Hardware removal was less frequent in the VLP group ($p<0.001$).

Discussion

Most Colles' fractures in elderly patients are a source of morbidity and loss of quality of life. Colles' fractures are among the most common injuries treated by orthopaedic, trauma and hand surgeons [22]. Factors such as fracture types, associated injuries, bone quality and general health of the patients should be considered when choosing treatment. Irrespective of the method used to treat distal radial fractures, we know that the most important factors that influence long-term results are early mobilisation and restoration of normal anatomy [4]. In our study, maintenance of reduction was better in the VLP group compared with the PKW group. In addition to restoring anatomy, the other real advantage of using locking plates was improved fracture stability. Our experience showed the subchondral bone of the distal radius could be adequately maintained by the fixed angled locking screws. The VLP group had greater ability to return to their previous work in three months after surgery when compared to the PKW group. We found that the locking plate gave very stable fixation with early wrist range of motion. The patients treated by this method had a greater ability to return to work and previous athletic activities in a shorter time.

In a study by Huard et al. [9], 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 plate group versus 50% of K-wire group). Voigt and Lill [21] reported that 89 distal radius extension fractures in the elderly were treated by a

Table 3 Mean functional outcome measures (±SD) and percentage of the normal side (%) at final follow-up for both groups

Measure	VLP	PKW	<i>P</i> value
Extension, degree (%)	62.4±10.2 (98%)	47.6±12.4 (77%)	0.04
Flexion, degrees (%)	70.2±7.9 (99%)	50.0±10.7 (72%)	<0.001
Pronation, degrees (%)	83.1±7.5 (96%)	82.7±8.6 (95%)	0.71
Supination, degrees (%)	84.6±9.1 (99%)	75.3±9.1 (89%)	0.12
Radial deviation, degrees (%)	24.1±8.8 (94%)	22.5±9.6 (93%)	0.67
Ulnar deviation, degrees (%)	41.7±6.9 (95%)	30.1±7.9 (62%)	0.03
Grip strength, kp (%)	28.9±6.7 (91%)	24.8±10.4 (84%)	0.23

VLP volar locking plating, PKW percutaneous Kirschner wiring

Fig. 2 A 64-year-old female patient with left displaced Colles' fracture was treated with closed reduction and percutaneous Kirschner wiring. **a** Preoperative anteroposterior and lateral radiographs showed an AO type-A3 fracture. **b** Radiographs at the immediate postoperative period showed good fracture reduction. **c** X-rays at final follow-up showed healed fracture without loss of reduction. Satisfactory outcome was achieved

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. We 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, only two fractures (6.5%) had loss of reduction in the VLP group. However, 15 fractures (48.4%) had loss of reduction in the PKW group. We thought that the

better radiological results in the VLP group might be due to the higher rigidity of the fixation.

Stevenson et al. [19] reported that 33 patients who had displaced distal radial fractures were treated by using volar locking plates. The mean age was 49.5 years (range 28–82 years). Their results confirm that open reduction and internal fixation using a locking plate is a suitable method for accurately reducing and maintaining the position of the majority of displaced distal radial fractures facilitating early mobilisation and functional recovery. However, Arora et al. [1] showed a different result. They reported that 114 patients older than 70 years with Colles' fractures were treated by volar locking plates ($n=53$) or closed reduction and casting ($n=61$). The complication rate was up to 13% in the locking plate group. Although the radiographic results were better in the surgical group compared to nonsurgical group, there was no improvement in the functional outcomes for the surgical treatments in patients older than 70 years. The poor correlation between the radiographic and functional outcomes in this age group might be related to decreased functional demand on the wrist [2, 20]. In our study, 31 Colles' fractures in patients between 50 and 70 years of age were treated by volar locking plates. High level of satisfactory outcome (90.3%) and low complication rate (3.2%) were noted. We determined that open reduction and internal fixation using volar locking plating is an adequate method for treating Colles' fractures in patients between 50 and 70 years of age facilitating early mobilisation and functional recovery. This is similar to the findings of Marcheix et al. treating Colles' fractures among the elderly [15]. Hull et al. [10] reported that 71 adult patients with Colles' fractures were treated by VLP ($n=36$) or PKW ($n=35$). They were unable to demonstrate a clinically relevant advantage of using volar locking plates over K-wires. This might be related to adult patients with good bone quality. K-wire fixation was stable enough to resist secondary displacement.

In our study, the VLP group had a low complication rate. There was no case related to skin necrosis or delay wound healing. We thought that short injury–surgery interval (under eight hours) 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 joint or damage the extensor tendons. In the PKW group, the pin site problems were not common (6.5%). Most of our K-wires were placed under skin, and this method lowers the risk of pin tract infection.

Our study had various limitations. First, it was a retrospective study and the patients were not matched according to the AO fracture type (A2, A3, C1-3) due to our small database. These could produce a selection bias.

Second, it was performed in two teaching institutions where the residents were the operating surgeons and the surgeons' level of experience could influence the outcomes. Third, it was not a large series and when we calculated the power of this study, most were 85–90%. If the null hypothesis (no difference between the groups) was accepted in our study, the false-negative rate was up to 10–15%.

In conclusion, for the treatment of dorsally displaced, extra-articular or simple intra-articular fractures of the distal part of the radius in patients between 50 and 70 years old, both PKW and VLP groups had high union rate and low complication rate. However, better functional results can be expected in association with open reduction and volar locking plating, and this form of treatment for patients might give a faster return to daily activities after the injury.

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