Int J Clin Exp Med 2018;11(2):1185-1191
www.ijcem.com /ISSN:1940-5901/IJCEM0042767

Original Article

Efficacy of volar locking plate fixation for unstable distal radius fractures in elderly patients

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Received September 20, 2016; Accepted January 8, 2017; Epub February 15, 2018; Published February 28, 2018

Abstract: Objective: This study was to investigate the efficacy of volar locking plate fixation for treating unstable distal radius fractures (DRFs) in elderly patients. Methods: Thirty one patients (78.6 ± 3.6 years, range 75-91 years) with unstable DRFs were studied. Patients received volar locking plate fixation and postoperative functional exercises. Results: Average operative time was 47.84 ± 8.68 min, and the average content of blood loss was 62.10 ± 11.67 mL. During the follow up of 4-12 months, excellent, good, middle and poor outcomes were obtained in 17, 11, 2 and 1 cases, respectively; that is to say, the good rate was 90%. Fracture healing appeared at postoperative 6.23 ± 0.62 weeks. There were radial palmar angle of 9.42 ± 3.02, ulnar deviation angle of 21.77 ± 0.88, radial shortening of 0.19 ± 0.65 mm and ulnar variance of -0.52 ± 0.47 mm. Conclusions: Volar locking plate fixation was effective to treat unstable DRFs in elderly patients.

Keywords: Distal radius fractures, volar locking plate, elderly patient, preoperative preparations, postoperative functional exercises

Introduction

Distal radius fracture (DRF) is one of the most common fractures of the upper extremity [1], as it accounts for 15% of all fractures [2]. Majority of DRFs are stable and treated with closed reduction and cast immobilization [3], whereas some DRFs are considered to be unstable [3] and require additional fixation [4]. In addition, closed reduction with cast immobilization is also not a good choice for elderly patients as it is prone to postoperative displacement and not well function recovery [5].

Many studies have documented that interlocking fixation is associated with good patient satisfaction, wrist function and restoration of physiological radius length [6-8]. Recently, volar locking plate is widely accepted as an efficient treatment for unstable DRFs due to the advantages of direct reduction, solid fixation as well as early mobilization of wrist fractures [9].

With the rising incidence of DRFs in an ageing population [10], the efficacy of volar locking plate for treating unstable DRF in elderly patients is not well known. Especially as the elderly patients usually have some comorbidities and osteoporosis, the anesthesia risk is high and it may be difficult to obtain good outcome via volar locking plate. A prospective randomized trial by Arora et al. found that older patients treated by volar locking plate fixation for displaced and unstable distal radial fractures had better grip strength than those by nonoperative treatment. Additionally, some other previous studies also found that there were many satisfactory results of the volar locking plate in elderly patients with unstable DRFs [11-15]. However, the patients in these studies were in a large range of age (49-78 years or 17-79 years) or their age were not very old (above 65 years).

Therefore, this retrospective study was aimed to investigate the efficacy of the locking plate fixation via volar approach for the treatment of unstable DRFs in elderly population (75 years old and older).

Materials and methods

Patient

This retrospective study reviewed a total of 31 elderly patients (2 males and 29 females; mean age 78.6 ± 3.6 years, range 75-91 years) with

Table 1. The demographic and clinical data of patients with unstable distal radius fractures (DRFs)

Parameter	Patients
Mean age (range), years	78.65 ± 3.64 (75-91)
Gender	
Male, n (%)	2 (6.5%)
Female, n (%)	29 (93.5%)
AO/ASIF classification, n (%)	
A3	15 (48.4%)
B3	6 (19.3%)
C1	8 (25.8%)
C2	2 (6.5%)
Waiting time before surgery, h	
≤ 24 h	24 (77.4%)
24-48 h	7 (22.6%)
Associated injury or comorbidities, n	
Fracture of femurs haft	5
Proximal humeral fractures	2
Hypertension or diabetes mellitus	22
Chronic bronchitis	12
Chronic atrial fibrillation	4

unstable DRFs who were treated by locking plate fixation via volar approach between February 2010 and February 2014. The inclusion criteria were: (1) a clinical diagnosis of unstable distal radius fractures according to the clinical features summarized by Cooney [16], including the pulverized cortex at the dorsal (volar) side of distal radius and displacement of articular surface greater than 2 mm; palmar angle tilting to the dorsal side > 20; radial shortening > 5 mm; anterior-posterior displacement more than 1 cm; and instability after fracture reduction and fracture prone to re-displacement. (2) an age of > 75 years; (3) patients who were able to take care of themselves before the injury. The indication for this surgery including types A3, B1, B3, C1 and C2 fractures on the basis of Association for Osteosynthesis/Association for the Study of Internal Fixation (AO/ASIF) [17], patients who were tolerant of anesthesia and surgery. Patient with unwillingness to taken the surgery, or with poor cardiopulmonary function, or who had senile dementia and can't actively cooperate with physiatrician for the postoperative functional exercises were all excluded. The demographic data consisting of age and gender and clinical data including AO/ASIF type, radiological measurements, waiting time before surgery and associated injury are shown in **Table 1**. Briefly, all fractures were closed fractures due to a fall on the outstretched wrist. The fractures were classified as: 15 cases of A3, 6 cases of B3, 8 cases of C1 and 2 cases of C2. Preoperative X-radiological measurements showed that palmar angle tilted from -30° to 5° with a mean angle of -3.77 ± 7.15°; ulnar deviation angled from 0° to 15° with an average of 8.87 ± 4.24°; and radial shortening ranged from 2 to 10 mm with an average of 6.61 ± 2.25 mm; and ulnar variance ranged from 0 to 10 mm with an average of 2.81 ± 1.80 mm. This study was approved by the ethical committee of Shanghai Pudong New District Zhoupu Hospital.

Preoperative preparations

As elderly patients were usually associated with hypertension or diabetes as well as other internal diseases, they all received positive nursing care to control blood glucose and blood pressure. Other preoperative preparations, including cardiopulmonary function assessment via cardiac ultrasonography, anesthesia risk evaluation by anesthetist, phlebothrombosis prophylaxis with low molecular heparin, routine CT scan as well as 3D reconstruction examines were all performed for the assessment of displacement fracture. Besides, as for patients associated with fracture of femurs haft who also had severe anemia (hemoglobin < 5 g/dL [18]), red cells transfusion was given to correct anemia and surgery was conducted as early as their general state of health was stable.

Operative procedure

After brachial (plexus) block anesthesia or general anesthesia, the patient was in supine position with the injured forearm extended on a small table beside the operating table. Pneumatic tourniquet was used to tie the upper arm. A volar incision was made starting at the shaft of radius, followed by a dissection to enter interspace between the flexor carpi radialis (FCR) muscle tendon and arteria radialis, and ended at distal wrist flexion crease, with pronator quadratus and broken ends of fractured bone exposed. Following partial excision of pronator quadratus, the fracture was reduced

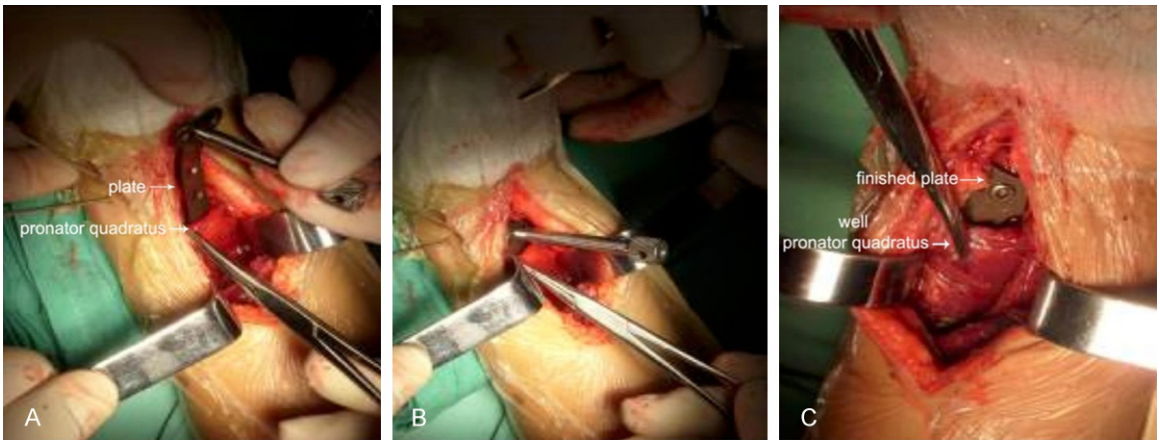

Figure 1. The surgical procedure on a female patient (76 years old) with type C1 unstable distal radius fractures. A: The volar locking plate was placed below pronator quadratus. B: Plate implant was finished. C: Locking screws were used for fracture fixation; well preserving pronator quadratus was (shown at the vascular clamps).

Table 2. Dienst wrist rating system

Grade	Excellent	Good	Moderate	Poor
Subjective evaluation				
Wrist pain	Absent	Now and then	Usually	Continuing
Function	Unlimited	Limited when taking aggravating activities	Slightly limited at work	Reduced working capability and limited physical labor
Objective evaluation				
Locomotor activity	Normal	Nearly normal	Reduced	Obviously reduced
Grip power	Normal	Nearly normal	Reduced	Obviously reduced
Loss of palmar flexion and dorsal expansion	< 15°	15-30°	30-50°	> 50°

and held temporarily with thin Kirschner wire. A volar locking plate with appropriate length was placed on to the volar radius, with distal plate 2-3 mm below the articular surface, and sliding hole was temporarily fixed. Then, at least 4 locking screws (all screws of 2.4 mm diameter; the radial one of 16 mm length, the middle two of 20 mm length and the ulnaris one of 18 mm length) were used for distal fracture fixation after the plate position confirmed radiographically and satisfactory reduction, and 3 screws (a cortical bone screw of 2.7 mm diameter and 16 mm length; the other two locking screws of 2.4 mm diameter and 14 mm length) were placed for proximal fracture fixation according to fracture condition. Finally after well fracture reduction and fixation were confirmed again, Kirschner wire was pulled out, following by suture. Five cases with fracture of femurs haft were also treated with closed reduction and PFNA internal fixation. Two cases with proximal humeral fractures were treated with open reduction and intramedullary nailing. A typical patient treated with volar locking plate fixation is shown in **Figure 1**.

Post-operation management

Antibiotics were used in 5 patients associated with fracture of femurs haft for infection prevention within 24 h, but not for others. Symptomatic treatments of pain and anti-osteoporotic medicine (Alfacalcidol, 0.5 μg/d) were given for all patients. During the oral administration of Alfacalcidol, 24-h collection of plasma and urine was conducted every three months for the detection of Calcium level. If hypercalcemia or hypercalcinuria occurred, Alfacalcidol would be forbidden until the blood calcium recovered to the normal. Then Alfacalcidol would be given at the half of the last dose. External fixation was not necessary. Early functional exercise was performed under the guidance of a physiatrician: first flexion and extension exercises of fingers, then flexion and extension exercise of wrist joint 2 weeks later, and finally weight-holding heavy exercise delayed to 8-10 weeks later (according to fracture healing by radioscopy), as well as gradual strength function training.

Table 3. Intraoperative and postoperative data of patients with unstable distal radius fractures (DRFs)

	Mean (range)
Operation time, min	47.84 ± 8.68 (30-70)
Blood loss, mL	62.10 ± 11.67 (40-90)
Fracture healing (range), weeks	6.23 ± 0.62 (6-8)
Active range of motion	
Palmar flexion	49.35 ± 5.82 (35-60)
Dorsal expansion	31.68 ± 3.76 (25-40)
Wrist pain	
0	14 (45.2)
1	4 (12.9%)
2	9 (29.0%)
3	1 (3.2%)
5	1 (3.2%)
Locomotor activity	
Normal	14 (45.2%)
Nearly normal	15 (48.4%)
Reduced	2 (6.5%)
Grip power	
Normal	1 (3.2%)
Nearly normal	28 (90.3%)
Reduced	2 (6.5%)

Follow-up

The intraoperative data consisting of operative time and blood loss were recorded, and postoperative data including palmar tilt, radial shortening, ulnar deviation and variance, fracture healing time and complications were all performed at follow-up. The wrist function was assessed under the Dienst wrist rating system [19] (**Table 2**), including the evaluation of active range of motion (ROM, palmar flexion and dorsal extension), wrist pain, and grip power measurement using a hydraulic dynamometer (Jamar, Clifton, New Jersey). Postoperative complications were recorded.

Statistical analysis

Statistical analysis was performed using SPSS 19.0 (SPSS Inc., Chicago, IL, USA). All results were reported as means ± standard deviation (M ± SD). The *t*-test was used to compare the preoperative and postoperative radiological measurements. $P < 0.05$ was considered as the statistical significance.

Results

The average operative time of the patients was 47.84 ± 8.68 min, with a range of 30-70 min (**Table 3**). The average blood loss content of the patients during surgery was 62.10 ± 11.67 mL, with a range of 40-90 mL. All patients were followed up for 4-12 months (average 7 months). According to Dienst wrist rating system, 17 patients obtained excellent outcome, 11 cases with good outcome, and 2 cases with moderate and 1 case with poor outcome, hence, the good rate was 90%.

Postoperative X-radiological examinations showed that fracture healing appeared at postoperative 6.23 ± 0.62 weeks in all patients, with a range of 6-8 weeks (**Table 3**). After surgery, the average of radial palmar angled increased significantly compared with preoperative measurements (9.42 ± 3.02° vs. -3.77 ± 7.15°, $P < 0.01$) (**Table 4**); the average of ulnar deviation angled increased significantly in postoperative measurements (21.77 ± 0.88° vs. 8.87 ± 4.24°, $P < 0.001$) (**Table 4**); the average of radial shortening reduced significantly (0.19 ± 0.65 mm vs. 6.61 ± 2.25 mm, $P < 0.001$) (**Table 4**), and the average of ulnar variance reduced significantly in postoperative X-radiological measurements (-0.52 ± 0.47 mm vs. 2.81 ± 1.80 mm, $P < 0.01$) (**Table 4**). No patients experienced loosening of the internal fixation, infection, or complications such as nerve and tendon injury (as a case shown in **Figure 2**). No reduction loss and aggravating displacement occurred after the surgery.

Among the three patients with middle or poor outcome, one case with plate at a distance of 5 mm from the articular surface had the reduction loss of articular surface at the follow-up of 1 month, as well as decreased wrist ROM, grip power and sometimes pain. The symptom was alleviated after the plate was removed one year later. In the other case with the screws entered into the distal radioulnar joint, the rotation function was also limited. The limited function was improved after removing internal fixation six months later. In the third case with plate partial to radialis, the flexion function of thumb was limited during the follow up.

Discussion

Generally, closed reduction and cast immobilization treatments were selected for elderly

Table 4. Preoperative and postoperative radiological measurements

Parameter	Radiological measurements		*P value*
	Preoperative	Postoperative	
Palmar tilt angle	-3.77 ± 7.15 (-30-5)	9.42 ± 3.02 (0-12)	$P < 0.01$
Ulnar deviation angle	8.87 ± 4.24 (0-15)	21.77 ± 0.88 (18-23)	$P < 0.001$
Radial shortening, mm	6.61 ± 2.25 (2-10)	0.19 ± 0.65 (0-3)	$P < 0.001$
Ulnar variance, mm	2.81 ± 1.80 (0-10)	-0.52 ± 0.47 (-1-0)	$P < 0.01$

The *t*-test was used to compare the preoperative and postoperative radiological measurements. $P < 0.05$ was considered as the statistical significance.

Figure 2. The radiological measurements of a female patient (75 years old) with type C2 unstable distal radius fractures: preoperative anteroposterior (A) and lateral (B) X-radiographs; postoperative anteroposterior (C) and lateral (D) X-radiographs showed that fractures and joint surface were anatomical reduction, and the internal fixation position was well.

especially for advanced aged DRF patients. However, as to the patients with unstable DRF and who were also associated with osteoporosis, plasters were not good choice of treatment to maintain fractures reduction and make for bone healing [5]. With the improvement of anesthesia and orthopedic fixation techniques, especially the appearance of lock plate, the stability of osteoporotic fractures was improved greatly, and volar DRF surgical techniques were also increasingly practiced in elderly patients [20]. In this study, we investigated the efficacy of the locking plate fixation via volar approach for the treatment of unstable DRFs in elderly population (75 years old and above). The results showed that most patients obtained good reduction and function recovery during the follow-up period, and no patients experienced loosening of the internal fixation, infection, or complications such as nerve and tendon injury, consistent with previous study by Orbay and Fernandez who reported that a volar fixed-angle plate provided stable internal fixation, good final results and minimized the complication rate in the elderly population [11]. However, a comparative study of clinical and radiologic outcomes reported that nonoperative treatment might be the preferred method of treatment in elderly population, in spite of better radiographic results (dorsal tilt, radial inclination, and radial shortening) in patients treated by volar fixed-angle plate fixation than those by cast immobilization [21], because unsatisfactory radiographic outcome in older patients did not necessarily translate into unsatisfactory functional outcome. Considering the shorter following-up in our study, a further prospective study with a long follow-up time was needed.

As most of elderly unstable DRF patients were usually associated with hypertension, diabetes, chronic bronchitis and other internal diseases, preoperative assessments of operative and anesthesia risks were necessary. Except for preoperative preparations, some details of operative procedure should be also noted: 1) For elderly unstable DRF patients with osteoporosis, especially female patients, Kirschner wire will be needed for temporary fixation after the completion of the reduction; the plate should be placed 2-3 mm under the articular surface. If it was too low below the articular surface, fixation would not be solid, as evidenced

by one case of postoperative re-displacement occurred in this study. 2) A good exposure is needed to avoid repeated fluoroscopic examination and prolonged operative time. The pronator muscle should be protected during the operation. Dos Remedios et al. [22] pointed out pronator muscle played an important role in the wrist function, including forearm rotation and distal ulnar joint stability. Above all, minimally invasive was advocated to avoid pronator muscle damage. 3) As to patients with type C2 fractures, especially who had crushing volar cortical bone, loss of the distal radius would occur even though Kirschner wire fixation was performed after reduction. Thus, it would be better to fix distal end of fracture firstly, then loosen oval foramen of the plate and draw again, and finally tight the screws after distal radius restoring to normal height. 4) Palmar approach might be associated with tendon rupture or other complications. Tarallo *et al*. [23] conducted a retrospective study to investigate the complication incidence s of volar locking plate fixation for unstable DRFs. The result showed that 18 of 303 (5.9%) DRFs patients suffered from complications after volar locking plate fixation and extensor tendon injury accounted for 50% of all complications due to technical defect of the internal fixation. In our study, we also found that the complications of volar locking plate fixation of DRFs were related to technical defects during internal fixation. Fortunately, this complication could be avoided by careful operative procedure. 5) For unstable DRFs, distal radioulnar join dislocation should be noticed and corrected timely. In our study, one patient obtained not well rotation function during follow-up because his dislocation was not observed in time. 6) The protection for soft tissue should be considered during the surgery because of the poor flexibility of the skin and soft tissues were relatively poor in elderly patients; the affected limbs should be elevated postoperatively to lessen edema.

Conclusion

Several limitations in our study must be addressed. The number of the cases included in the study and follow-up period were insufficient. Comparison between non-operative treatment and volar locking plate fixation was not performed. Thus, further prospective studies with large population and long follow-up time were required to evaluate the clinical outcomes of DRFs in elderly patients by volar locking plate fixation. Not with standing its limitation, this study did suggest that volar locking plate fixation combined with preoperative preparation may be a good choice for treating unstable DFRs in elderly patients, who were able to take care of themselves before the injury. It should provide a therapeutical reference for DRFs elderly patients, especially in the graying of society.

Acknowledgements

This study was carried out in Shanghai Pudong New District Zhoupu Hospital. This study was supported by the training of academic leader of Pudong New Area health system (Contract No: PWRd2014-15).

Disclosure of conflict of interest

None.

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