Annals of Medicine and Surgery 18 (2017) 28–32

Contents lists available at ScienceDirect

Annals of Medicine and Surgery

journal homepage: www.annalsjournal.com

Comparison of outcome of VLCP versus PKEF in the treatment of AO type C2-3 distal radial fractures

Zhibing Tang [a, b], Jinlian Liu [b], Huilin Yang [a, *]

[a] The Department of Orthopaedic Surgery, The First Affiliated Hospital of Soochow University, Suzhou, Jiangsu, China
[b] The Department of Orthopaedic Surgery, Suzhou Kowloon Hospital, Shanghai Jiaotong University School of Medicine, China

HIGHLIGHTS

- This is a retrospective study.
- The purpose of this study was to compare the therapeutic effects of the VLCP and PKEF in the treatment of the AO type C2-3 distal radial fractures.
- Both techniques could get satisfactory results in the treatment of AO type C2-3 fractures, but PKEF leads to better wrist function than VLCP.

ARTICLE INFO

Article history:
Received 23 January 2017
Received in revised form
11 May 2017
Accepted 11 May 2017

Keywords:
Distal radial fracture
Reduction
Fixation

ABSTRACT

Purposes: Fractures of the distal radius are extremely common in adults. However, the optimal management remains controversial, especially in AO type C2-3 (Type23 C2 or C3 of distal radial fracture, according to AO classifications). The purpose of this study was to compare the results of the volar locking compression plate (VLCP) and percutaneous Kirschner-wires combined with external fixation (PKEF) in the treatment of the AO type C2-3 fractures.

Methods: From July 2012 to June 2015, 62 patients with AO type C2-3 fractures, treated by VLCP or PKEF, were included in this retrospective study. Patients were followed up at 3 months, 6 months after operation, and final follow up. Outcomes were assessed by radiographic features in all follow up and by DASH and Sarmiento's modification of the Gartland-Werley score at final follow up.

Rusults: No significant difference was noted between these two groups in terms of volar inclination, ulnar angulation and ulnar variance. There was also no significant difference on DASH score between these two groups. However, according to the Sarmiento's modification of the Gartland-Werley scores, the scores was higher in VLCP group than the PKEF group, and ratings of excellent and good were lower in the VLCP group ($P = 0.05$).

Conclusions: Both techniques could get satisfactory results in the treatment of AO type C2-3 fractures, but PKEF leads to better wrist function than VLCP .

1. Introduction

Fractures of the distal radius are the most common fractures and account for an estimated 17% of all fractures diagnosed [1]. With the ageing of the population and subsequent increase inosteoporosis, and also with the growing participation in outdoor sports, the incidence of comminuted distalradial fracture is increasing day by day. Generally, fractures of the distal radius could be treated non-operatively, if the fracture fragments could be reduced by closed method and kept immobilized in good alignment with a plaster cast. But for AO type C2-3 distal radial fractures, it is difficult to reduce and stabilize in the anatomical position by manual reduction and plaster cast immobilization because of its multi-fragmentary nature and these is high incidence of loss of correction inside the cast.

Reconstruction of the articular congruity and stable fixation are the most important thing for treating unstable distal radial fractures, and it allows early functional recovery and reduce post-operational complications [2–4]. But comminuted intraarticular distal radius fractures (AO type C2-3) are typically the most challenging to surgically treat even. The possible surgical treatment

* Corresponding author. Department of Orthopaedic Surgery, The First Affiliated Hospital of Soochow University, 188 Shizi St, Suzhou, Jiangsu, 215006, China.
E-mail addresses: tzb1985826@163.com (Z. Tang), suzhoutrauma@126.com (H. Yang).

http://dx.doi.org/10.1016/j.amsu.2017.05.006

options for AO type C2-3 fractures are percutaneous reduction with the K-wires, the external fixation (EF), the open reduction and internal fixation (ORIF) with plate [5–9]. Due to ambiguity of the results, the optimal method of treatment for AO type C2-3 fractures in adults remains controversial [10–12].

The purpose of this study was to compare the final outcome of the ORIF with volar locking compression plate (VLCP) and closed reduction with percutaneous Kirschner-wires combined with external fixation (PKEF) for the treatment of AO type C2-3 fractures in adults.

2. Materials and methods

Inclusion criteria of this study were age 18 years or older, fresh AO type C2-3 fractures (Injury time to operations <14 days), and no prior injury and surgery to the same limb. Exclusion criteria were the second surgery, concomitant fractures of the same limb, and patients with significant comorbidities like ischemic heart disease, poorly controlled diabetes, obesity, severe osteoporosis and smoking.

Strictly following the inclusion and exclusion criteria, patients were included in the study who were either treated by ORIF with VLCP or closed reduction and fixation by PKEF in the authors' institution from July 2012 to June 2015. All surgical procedures were performed by senior doctors of trauma team using standard protocols under regional or general anesthesia, and an accept ablereduction was defined as less than 2 mm of intra-articular step or gap as well as volar tilt of 0° to plus 15°.

2.1. Surgical technique

In the PKEF group, 3.5 mm schanz pins were used for the proximal radial shaft and 2.5 mm pins for the second metacarpal. The pins were interconnected with solid connecting rod and link joints (IRENEOrthopaedic Device Co Ltd, Taijin City, China). We used 1.5 mm or 2.0 mm K wires around the fracture site to help reduction, and then fracture fragments were fixed with the K-wires, reduction was checked in the C-arm in antero-posterior and lateral views. Distal radial articular surface, radial height, ulnar angulation, and volar tilt were checked. When accept ablereduction was achieved, external fixator was applied. The K-wires and external fixator were removed after 6–8 weeks. Hand physiotherapy was started as soon as possible after surgery and active and passive wrist exercises were stared after removal of the implants(Fig. 1).

In the VLCP group, the distal radial fractures were exposed by a modified Henry approach, the interval of dissection was between the flexor carpi radialis (FCR) and the radial artery. The pronator quadratus was split from the radial border, and the muscle was retracted ulnarly. The volar aspect of the distal radius and the fracture were identified. The fracture was reduced using direct and indirect means. When necessary, wrist capsule was incised to examine the articular surface and autogenous bone graft was added. A volar locking compressionplate (Synthes, Bettlach, Switzerland or Zimmer, USA) was applied on the volar aspect of the

Fig. 1. Preoperative AP and lateral radiograph (1A) of a 58 year-old man who sustained an distal radial fracture, AP and Lateral radiographs (1B) immediately after close reduction with PKEF. AP and lateral radiographs (1C) before remove fixation. AP and lateral radiographs (1D) during the final follow-up time.

distal radius.The reposition of the fragments and localization of the plate were rechecked with C-arm fluoroscopy.After the wound was closed, a short arm plaster cast was applied for 2 weeks in severely osteoporotic patients. Standard rehabilitation program was started immediately after the surgery in most of the patients, but the wrist movements were withheld for two weeks in severly osteoporotic patients and started as soon as plaster cast was removed(Fig. 2).

Operative time, complications, and union time of the 2 groups were recorded. Volarinclination, ulnar angulation, and ulnar variance were measured on anteroposterior and lateralradiographs at each follow up time (Immediately after surgery, 3 months and 6 months after operation and the final follow up). Fracture union was determined by physical examination of the wrist and radiological study. Each patient was evaluated according to DASH score (The DASH score ranges from 0 to 100, with the lower numbers indicating a lower level of disability.) and the modification of the Gartland-Werley score by Sarmiento et al. at the last follow up [13,14]. (The modified Gartland-Werley score is a physician-based demerit scoring system. The score ranges from 0 to 52 points: excellent, 0–2 points; good, 3–8 points; fair, 9–20 points; poor, more than 21 points.)

2.2. Ethics approval

Prior approval was obtained from Suzhou Kowloon Hospital Shanghai Jiao Tong University School of Medicine Human Research Ethics Committee (2010-005-C7)to conduct this study. This study has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

2.3. Statistical analyses

Statistical analyses were performed with the SPSS version 18.0 statistical software package (SPSS Inc, Chicago, Illinois). Continuous variables were recorded as mean ± SD. They were tested using the *t*-test, and the rates were compared using Fisher's exact test. $P < 0.05$ was considered statistically significant.

3. Results

The VLCP group included 40 patients (12 men and 28 women) with a mean age of 57.6 years (range, 26–78 years). The dominant hand was involved in 32 patients. According to the AO classification: 16 were C2 subtype, and 24 were C3 subtype. The interval between injury and index operative procedure is 6.1 days in average (range, 0–11 days). Among these 40 cases, fifteen were caused by high-energy injuries and 25 by low-energy injuries.

The PKEF group included 22 patients (Eight men and 14 women) with a mean age of 52.8 years (range, 29–76 years). The dominant hand was involved in 16 patients. According to AO classification, 10 were type C2, and 12 were type C3. The interval between injury and index operative procedure is 4.8 days in average (range, 0–9 days). Among these group, six were caused by high-energy injuries and 16 by low-energy injuries.

Mean follow-up time was 32.8 months in VLCP group and 30.6 months in PKEF group. No statistically significant differences

Fig. 2. Preoperative AP and L radiograph (2A) of a 52 year-old woman. AP and Lateral radiographs (2B) immediately after open reduction and internal fixation with VLCP. AP and lateral radiographs (2C) during the final follow-up time.

Table 1
Patient's data.

Variable	VLCP Group	PKEF Group	p
Female, No(%)	28 (70.00%)	14 (63.63%)	>0.05
Mean age, year	54.30 ± 15.20	55.82 ± 15.86	>0.05
Dominant hand injury, No(%)	32 (80.00%)	16 (72.72%)	>0.05
High-energy injury, No(%)	15 (37.50%)	6 (27.27%)	>0.05
The interval between injury and surgery, day	6.06 ± 3.55	4.87 ± 2.93	>0.05
Mean operative time, min	71.23 ± 14.58	63.19 ± 13.25	>0.05
Mean union time, week	12.69 ± 1.51	11.96 ± 1.83	>0.05

existed between these two groups in terms of age, sex, dominant hand injury, causes of injuries and operative time (Table 1). Post-operative complications occurred in three patients, one had a mild subcutaneous infection in the PKEF group. Other two were in VLCP group. One developed complex regionalpain syndrome, and in another case reduction was lost partially. All these three patients were treated conservatively. No nonunion, or malunion occurred in our series, and no patient required revision surgery. No statistically significant differences was found between these two groups in mean volar inclination, ulnar angulation, or ulnar variance immediately, three months, six months postoperatively and at final follow up (Table 2).

There was no significant difference in mean DASH scores in patients between these two groups at the final follow up (8.51 ± 1.49 VS 7.48 ± 1.67). However, we observed a vast difference in wrist function in patients treated with PKEF compared to patients treated with VLCP, with a modified Gartland-Werley scores of 7.30 ± 6.06 and 5.31 ± 4.29, though the result is not statistically significant (P = 0.05). The ratings of excellent and good were found in 72.50% in the VLCP group and 86.36% in the PKEF group (Table 3).

4. Discussion

AO type C2-3 distal radius fractures are the most difficult to reduce and stabilize in the anatomical position because of its multifragmentary nature. The aim of treatment in this fracture is restoration of articular congruity, axial alignment, maintenance of reduction and preservation of function. Poor reduction of the articular surface has been shown to correlate with post-traumatic arthritis [15], and malalignment would decrease grip strength, reduce range of motion and instability [16]. Different surgical strategies are available for treating unstable intra-articular distal radius fractures, but the best treatment option for this injury remains controversial.

Table 2
Post-op Radiographic Features of the two Groups.

	VLCP Group	PKEF Group	P
Volar inclination, deg			
Immediately	12.22 ± 1.73	11.20 ± 1.82	0.89
3 months	12.09 ± 1.66	11.11 ± 1.77	0.92
6 months	12.03 ± 1.65	11.07 ± 1.79	0.86
Finial follow-up	12.00 ± 1.64	11.02 ± 1.77	0.88
Ulnar angulation, deg			
Immediately	21.65 ± 2.12	20.73 ± 2.08	0.73
3 months	21.51 ± 2.07	20.26 ± 2.22	0.94
6 months	21.43 ± 2.06	20.10 ± 2.20	0.98
Finial follow-up	21.31 ± 2.03	19.68 ± 2.52	0.66
Ulnar variance, mm			
Immediately	−0.65 ± 0.67	−0.51 + 0.82	0.39
3 months	−0.57 ± 0.65	−0.41 ± 0.87	0.22
6 months	−0.56 ± 0.63	−0.40 ± 0.90	0.19
Finial follow-up	−0.55 ± 0.63	−0.39 ± 0.92	0.18

Table 3
Comparison of Functional Scores at final follow-up time.

Post-op time	VLCP Group	PKEF Group	p
DASH Scores	8.51 ± 1.49	7.48 ± 1.67	0.51
Gartland-Werley scores	7.30 ± 6.06	5.31 ± 4.29	0.05
Excellent and good rate	72.50%	86.36%	0.17

External fixation (EF) augmented with or without additional Kirschner-wires relies on ligamentotaxisto obtain and maintain fracture alignment [17]. EF has the ability to maintain the reduction until the fractures healed. And this technique has many advantages, such as it is less invasive, so provides less surgical trauma and relatively easy to apply.

Since the introduction of VLCP, open reduction and internal-fixation (ORIF) has become more popular in the treatment of distal radial comminuted fractures [18].By direct visualization and manipulation of the fracture fragments, stable rigid fixation could be achieved by this technique. It allows early mobilization and may result in more rapid recovery and improved wrist function [19,20]. But, still there is no conclusive evidence favoring ORIF with VLCP over external fixation or vice versa [21].

Kumbaraci et al. reported a retrospective study comparing EF versus VLCP in the treatment of AO type-C distal radius fracture, and showed that the radiological parameters of the VLCP group were better than PKEF group [22].However, in our study, no significant differences in mean volar inclination, ulnar angulation, or ulnar variance were found immediately, 3 months, 6 months postoperatively or even at final follow up time. We found that both VLCP and PKEF could provide satisfactory reduction and enough stability for AO type C2-3 distal radial fractures. We analyzed the reason is that the distal radial fractures performed with PEKF provided better reduction and stability than only with external fixation.

There was no significant difference in mean DASH scores in patients between these twogroups at the final follow-up time. However, we observed a vast difference in wrist function inpatients treated with PKEF compared to patients treated with VLCP according to modified Gartland-Werley score at final follow up, though the result is not statistically significant. Grewal R et al. had reported that 45 unstable distal fractures treated with ORIF or closed reduction and percutaneous fixation, VLCP group had advantages in the early postoperative period, but overall scores equalized at 1 year [23]. Marcheix et al. showed that 103 patients (aged more than 50 years old)with unstable extra-articular and intra-articular fractures treated with pins fixation or volarfixed-angle plate. At 3 and 6 months, the plated patients had better objective functional results, but at one year after operation, the DASH scores were similar between the groups [24]. Rajeev Shukla et alrandomized 106 patients with unstable distal radial fractures to VLCP or EF. At 3 and 6 months, the plated patients had better Green and O'Brien scores, but at one year results of EF showed superiority over VLCP [25]. The results of these studies were similar to our findings. Though VLCP allow faster early rehabilitation than PKEF, PKEF has smaller interventions to soft tissue. So functional recovery in terms of long term wrist functions is better in this group.

5. Conclusion

Both VLCP and PKEF techniques could give satisfactory results in the treatment of AO typeC2-3 distal radial fractures. We observed a vast difference in wrist function in patients treated with PKEF compared to patients treated with VLCP, with a modified Gartland-

Werley scores of 7.30 ± 6.06 and 5.31 ± 4.29, though the result is not statistically significant (P = 0.05), So we think that PKEF technique has superiority over VLCP at wrist functions recovery at final follow up, and we would recommend PKEF technique for treating AO typeC2-3 distal radial fractures. The current study was a non-randomized, comparative trial and having some limitations like small sample size, short follow-up, and lack of multiple factors analysis. So we also recommend further evaluation of our findings by a prospective randomized, comparative studies with larger sample sizes.

Ethical approval

Prior approval to conduct this study was obtained from Suzhou Kowloon Hospital Shanghai Jiao Tong University School of Medicine Human Research Ethics Committee (2010-005-C7). Therefore, this study has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Funding

Scientific and technological project of Suzhou (NO. SYS201511).

Author contribution

Zhibing Tang: data analysis, writing.
Jinlian Liu: data collections.
Zheng Wang : data analysis.
Huilin Yang: study design.

Conflicts of interest

The authors declare that they have no conflict of interest.

Guarantor

Huilin Yang.

Research registration unique identifying number (UIN)

We have registered at http://www.researchregistry.com, but the UIN will give to us next week, thanks.

References

[1] B.R. Singer, G.J. McLauchlan, C.M. Robinson, J. Christie, Epidemiology of fracturesin 15,000 adults: the influence of age and gender, J. Bone Jointsurg. Br. Vol. 80 (2) (1998) 243–248.
[2] D.A. Campbell, Open reduction and internal fixation of intra articular and unstable fractures of the distal radius using the AO distal radius plate, J. Hand Surg. Edinb. Scotl. 25 (6) (2000) 528–534.
[3] M. McQueen, J. Caspers, Colles fracture: does the anatomical result affect the final function, J. Bone Jt. Surg. Br. Vol. 70 (4) (1988) 649–651.
[4] S. Giannotti, P. Alfieri, L. Magistrelli, F. Casella, L. Palmeri, G. Guido, Volar fixation of distal radialfracture using compression plate: clinical and radiographic evaluation of 20 patients, Musculoskelet. Surg. 97 (1) (2013) 61–65.
[5] B. Twigt, M. Bemelman, K. Lansink, L. Leenen, Type C distal radial fractures treated with conventional AO plates: an easy and cost-saving solution in a locking plate era, Int. Orthop. 37 (3) (2013), 483–438.
[6] H.J. Kreder, D.P. Hanel, J. Agel, et al., Indirect reduction and percutaneous fixation versus open reduction and internal fixation for displaced intra-articular fractures of the distal radius: a randomised,controlled trial, J. Bone Jt. Surg. Br. Vol. 87 (6) (2005) 829–836.
[7] D.A. Rikli, K. Kupfer, A. Bodoky, Long-term results of the external fixation of distal radius fractures, J. Trauma 44 (6) (1998) 970–976.
[8] F. Leung, Y.K. Tu, W.Y. Chew, S.P. Chow, Comparison of external and percutaneous pin fixation with plate fixation for intra-articular distal radial fractures. A randomized study, J. Bone Jt. Surg. Am. 90 (1) (2008) 16–22.
[9] G.R. Sennwald, S.D. Della, Unstable fracture of the distal radius and its treatment: comparison of three techniques: external fixation, intramedullary pinning and AO plates, Chir. la Main 20 (3) (2001) 218–225.
[10] Z. Margaliot, S.C. Haase, S.V. Kotsis, H.M. Kim, K.C. Chung, A meta-analysis of outcomes of external fixation versus plate osteosynthesis for unstable distal radius fractures, J. Hand Surg. Am. 30 (6) (2005) 1185–1199.
[11] T.W. Wright, M. Horodyski, D.W. Smith, Functional outcome of unstable distal radius fractures: ORIF with a volar fixed-angle tine plate versus external fixation, J. Hand Surg. Am. 30 (2) (2005) 289–299.
[12] M.M. Walenkamp, A. Bentohami, M.S. Beerekamp, et al., Functional outcome in patients with unstable distal radius fractures, volar locking plate versus external fixation: a meta-analysis, Strateg. trauma Limb Reconstr. (Online) 8 (2) (2013) 67–75.
[13] J.J. Gartland Jr., C.W. Werley, Evaluation of healed Colles' fractures, J. Bone Jt. Surg. Am. 33-A (4) (1951) 895–907.
[14] A. Sarmiento, G.W. Pratt, N.C. Berry, W.F. Sinclair, Colles' fractures. Functional bracing in supination, J. Bone Jt. Surg. Am. 57 (3) (1975) 311–317.
[15] T.E. Trumble, S.R. Schmitt, N.B. Vedder, Factors affecting functional outcome of displaced intra-articular distal radius fractures, J. Hand Surg. Am. 19 (2) (1994) 325–340.
[16] S. Kamei, D. Osada, K. Tamai, et al., Stability of volar locking plate systems for AO type C3 fractures of the distal radius: biomechanical study in a cadaveric model, J. Orthop. Sci. 15 (3) (2010) 357–364.
[17] D.J. Slutsky, Nonbridging external fixation of intra-articular distal radius fractures, Hand Clin. 21 (3) (2005) 381–394.
[18] J. Orbay, Volar plate fixation of distal radius fractures, Hand Clin. 21 (3) (2005) 347–354.
[19] M. Hakimi, P. Jungbluth, J. Windolf, M. Wild, Functional results and complications following locking palmar plating on the distal radius: a retrospective study, J. Hand Surg. Eur. Vol. 35 (4) (2010) 283–288.
[20] J.J. Dias, C.C. Wray, J.M. Jones, P.J. Gregg, The value of early mobilisation in the treatment of Colles' fractures. The Journal of bone and joint surgery, Br. Vol. 69 (3) (1987) 463–467.
[21] H.D. Kvernmo, Y. Krukhaug, Treatment of distal radius fractures, Tidsskrift for den Norske laegeforening: tidsskrift for praktisk medicin, ny raekke 133 (4) (2013) 405–411.
[22] M. Kumbaraci, L. Kucuk, L. Karapinar, C. Kurt, E. Coskunol, Retrospective comparison of external fixation versus volar locking plate in the treatment of unstable intra-articular distal radius fractures, Eur. J. Orthop. Surg. Traumatol. Orthop. Traumatol. 24 (2) (2014) 173–178.
[23] R. Grewal, J.C. MacDermid, G.J. King, K.J. Faber, Open reduction internal fixation versus percutaneous pinning with external fixation of distal radius fractures: a prospective, randomized clinical trial, J. Hand Surg. Am. 36 (12) (2011) 1899–1906.
[24] P.S. Marcheix, A. Dotzis, P.E. Benko, J. Siegler, J.P. Arnaud, J.L. Charissoux, Extension fractures of the distal radius in patients older than 50: a prospective randomized study comparing fixation using mixed pins or a palmar fixed-angle plate, J. Hand Surg. Eur. Vol. 35 (8) (2010) 646–651.
[25] R. Shukla, R.K. Jain, N.K. Sharma, R. Kumar, External fixation versus volar locking plate for displaced intra-articular distal radius fractures: a prospective randomized comparative study of the functional outcomes, J. Orthop. Traumatol. 15 (4) (2014) 265–270.