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*Original Article*

# Volar locking plate fixation versus Kirschner wire fixation in distal radius fractures: a meta-analysis

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**Abstract:** Objective: The superiority of volar locking plate fixation and K-wire fixation on treatment of distal radius fractures was controversial. Thus, we performed a meta-analysis to compare the efficacy of volar locking plate and K-wires for distal radius fracture. Methods: We searched Embase, Medline and PubMed for randomized controlled trials which compare the effects of volar locking plate and K-wire on treatment of distal radius fracture. Data analysis was performed by using the RevMan5. Results: Six studies met the inclusion criteria. The meta-analysis results showed volar locking plate fixation led to better DASH scores at 3 and 12 months, faster recovery of grip strength, extension and supination at 3 months. But there was no significant difference at 12 months in term of functions and motions recovery. Complications of the two methods were similar. Conclusion: The patients receiving fixation with volar locking plate for the treatment of distal radius fracture achieved an early recovery of function compared to those with K-wire.

**Keywords:** Distal radius fractures, fracture fixation, internal, volar locking plate, kirschner wire, meta-analysis

## Introduction

Distal radius fracture is one of the most common orthopedic injuries, which occurs in a proportion of approximate 25% [1]. It affects all age groups and is more common in older patients especially those with osteoporosis [2].

Therapeutic alternatives for distal radius fracture included surgical and non-surgical treatment. Non-surgical treatment is used if the bone fragments can be held in anatomical alignment by a plaster cast or orthotic device. If this is not possible, surgical fixation is performed. External fixation (EF) with Kirschner (K)-wire has historically been used for distal radius fractures [3-5]. More recently, internal fixation (IF) with a volar locking plate is becoming popularity and trends to replace K-wire fixation [6]. Favorers suggest that internal fixation with a volar locking plate results in a rapid functional recovery. However, the others favor K-wire because it is less expensive and has smaller surgical trauma with shorter operation time. To data, the therapeutic option for distal radius fractures is still controversial.

Recently, some meta-analyses of randomized controlled trials (RCTs) have compared EF with IF for treatment of distal radius fractures [7-9]. Those studies compared different types of plate fixations with K-wire fixation or other EFs. There was still lack of study directly comparing volar locking plate with K-wire. Thus, we performed this meta-analysis to evaluate clinical outcomes comparing volar locking plate fixation with K-wire fixation.

## Materials and methods

### *Search strategy and inclusion criteria*

We searched Embase, Medline and PubMed for RCTs from January 1990 to August 2014. The key words “distal radius fracture” with the limits “randomized controlled trial” were used in screening relevant citations. Language restriction was not imposed in our search. The inclusion criteria were: (1) the studies were random-

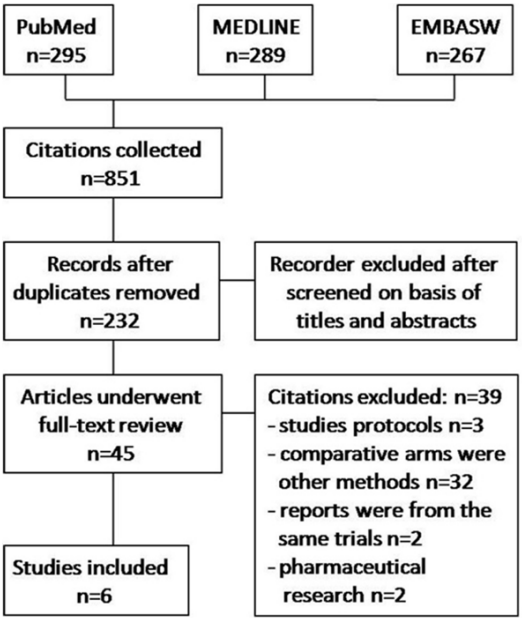


**Figure 1.** Flow diagram of the studies identified.

ized controlled trials on patients with distal radius fractures; (2) the studies compared volar locking plate with Kirschner wire; (3) the fellow up was above 12 months.

*Data extraction and quality assessment*

The following information from each study was extracted independently by two reviewers: first author name; year of publication; number of patients; the disabilities of arm, shoulder, and hand (DHAS) score; patient rated wrist evaluation (PRWE) score; grip strength; range of motion; number of complications. The complications during the 12 months follow up were analyzed. The Jadad score was used to assess the quality of the included studies [10]. The studies with score no less than 3 were regarded as high quality RCTs, while studies with score less than 3 were defined as low quality RCTs.

*Data analysis*

We measured the primary outcome DASH and PRWE scores and the outcomes of grip strength, forearm range of motion and complication parameters. Data analysis was performed by using the RevMan5. For each individual study, dichotomous data were reported as odds ratio (OR) with 95% CI and continuous data were reported as weighted mean difference (WMD) with 95% CI. Heterogeneity between studies was assessed by I-square test. A significant level of no less than 50% for I-square test was considered as evidence of heterogeneity. Fix effect model was used when there was no evidence of heterogeneity, otherwise random effect model was chosen. To evaluate the stability of the results of this meta-analysis, we performed a one-way sensitivity analysis, in which we evaluated the influence of individual studies by estimating the average relative risk in the absence of each study [11].

## Results

*Search results and characteristics*

A total of 851 citations were obtained via database searches; six met the inclusion criteria for this study (**Figure 1**). A total of 820 patients with distal radius fractures were involved in this study, in which 409 patients were treated with volar locking plates, and 411 patients were treated with K-wires. The information in these citations is summarized in **Table 1**. Because of the obvious nature of intervention, it is impossible to perform double blind. All 6 studies have been assessed by Jadad score system with score no less than 3 (**Table 1**).

*Comparison of the effects of volar locking plate and K-wire on PRWE and DHAS score*

The results showed the volar locking plate had better DASH scores at 3 and 12 months (**Table 2**; Supplementary Figure 1). The sensitivity analysis showed the results were robust (**Table 2**). We also compared the volar locking plate and K-wire on PRWE scores. At 12 months, the scores were not statistically different (Supplementary Figure 2; **Table 2**).

*Comparison of the effects of volar locking plate and K-wire on grip strength and range of motion*

Grip strength analysis at 3 months showed that there was a significant difference favoring volar locking plate over K-wire, but the difference neutralized over time; at 12 months the scores were not statistically significant different (**Table 3**; Supplementary Figure 3).

The data of range of motion were extracted from 3 to 5 studies. A significant difference in extension and supination was found in favor of

**Table 1.** Main characteristics of the included studies

| Study | Age | No. of patients (VLP/K-W) | Fracture types | Classification of fractures | Follow up | Jadad score |
|---|---|---|---|---|---|---|
| Egol et al. 2008 [12] | 18-87 | 44/44 | Unstable distal radial fractures | AO type A, B, C | 12 | 3 |
| Rozental et al. 2009 [13] | 19-79 | 23/21 | Unstable distal radial fractures | AO type A2, A3, C1, C3 | 12 | 3 |
| Wei et al. 2009 [14] | > 18 | 12/22 | Unstable distal radial fractures | AO type A3, C1, C2, C3 | 12 | 3 |
| Wilcke et al. 2011 [15] | 20-69 | 33/30 | Dorsally displaced distal radius fracture | AO type A, C | 12 | 3 |
| Karantana et al. 2013 [16] | 18-73 | 66/64 | Displaced distal radial fractures | AO type A3, C2, C3 | 12 | 3 |
| Costa et al. 2014 [17] | > 18 | 231/230 | Dorsally displaced distal radius fracture | AO type A, B, C | 12 | 3 |

**Table 2.** Comparison of volar locking plate and K-wire regarding the PRWE and DHAS

| | Time | Study | VLP | K-wire | WMD (95% CI) | *P*-value | Favored | Credibility |
|---|---|---|---|---|---|---|---|---|
| PRWE | 3 M | 2 | 242 | 239 | -9 (-23.3, 5.4) | 0.22 | | Not robust |
| | 12 M | 2 | 228 | 231 | -1.8 (-4.8, 1.2) | 0.23 | | Robust |
| DASH | 3 M | 5 | 169 | 172 | -15.9 (-22.3, -9.5) | < 0.0001 | VLP | Robust |
| | 12 M | 6 | 368 | 376 | -5.3 (-8.7, -1.9) | 0.002 | VLP | Robust |

**Table 3.** Comparison of volar locking plate and K-wire regarding the grip strength

| | Time | Study | VLP | K-wire | WMD (95% CI) | *P*-value | Favored | Credibility |
|---|---|---|---|---|---|---|---|---|
| Grip strength | 3 M | 4 | 148 | 151 | 15.4 (7.1, 23.6) | 0.0003 | VLP | Robust |
| | 12 M | 4 | 149 | 154 | 6.1 (-2.5, 14.7) | 0.17 | | Not robust |

**Table 4.** Comparison of volar locking plate and K-wire regarding the range of motion

| Time | | Study | VLP | K-wire | WMD (95% CI) | *P*-value | Favored | Sensitivity analysis |
|---|---|---|---|---|---|---|---|---|
| 3 M | Flexion | 5 | 169 | 172 | 4.3 (-0.5, 9.1) | 0.08 | | Robust |
| | Extension | 5 | 169 | 172 | 10.5 (3.1, 17.8) | 0.005 | VLP | Robust |
| | Supination | 5 | 169 | 172 | 10 (3.2, 16.7) | 0.004 | VLP | Robust |
| | Pronation | 5 | 169 | 172 | 7.3 (0.8, 13.9) | 0.03 | | Not robust |
| | Ulnar deviation | 4 | 103 | 108 | 2.6 (-2.5, 7.7) | 0.32 | | Robust |
| | Radial deviation | 4 | 103 | 108 | 8.5 (-11.1, 28) | 0.4 | | Robust |
| 12 M | Flexion | 5 | 170 | 175 | 0.12 (-2.8, 3) | 0.94 | | Robust |
| | Extension | 5 | 170 | 175 | 0.9 (-2.6, 4.4) | 0.61 | | Robust |
| | Supination | 5 | 170 | 175 | -0.9 (-2.9, 1.1) | 0.38 | | Robust |
| | Pronation | 5 | 170 | 175 | 0.5 (-0.8, 1.8) | 0.43 | | Not robust |
| | Ulnar deviation | 4 | 104 | 106 | 2.6 (-0.4, 5.6) | 0.09 | | Not robust |
| | Radial deviation | 4 | 104 | 106 | 1.2 (-3.3, 5.7) | 0.6 | | Robust |

volar locking plate at 3 months postoperatively (**Table 4**; Supplementary Figure 4). However, the range of motion of two therapies was similar at 12 months.

*Meta-analysis of complications*

All the included studies had reports of total surgical complications. Meta-analysis results showed that there was no significant difference between volar locking plate and K-wire at 12 months (OR = 0.76, 95% CI 0.54 to 1.08; P = 0.12) (**Figure 2**).

*Sensitivity analysis and publication bias*

Sensitivity analysis showed the outcomes of PRWE score and pronation at 3 months and grip strength, pronation and ulnar deviation at 12 months were not robust, which suggested the result was not credible. The funnel plot based on studies with data on total complica-

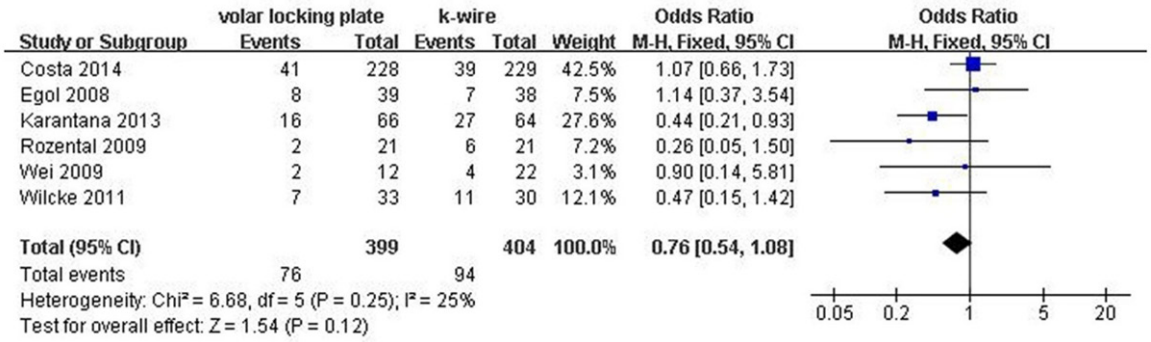


**Figure 2.** Comparison of the effects of volar locking plate and K-wire on complications.

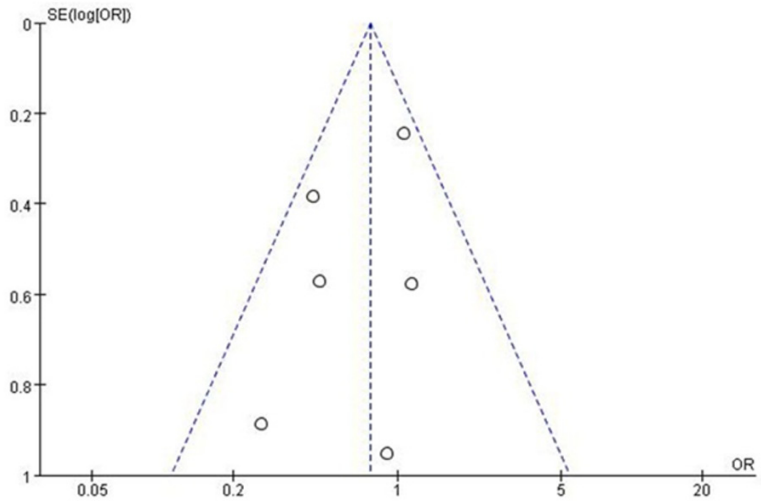


**Figure 3.** Funnel plot to assess publication bias in the meta-analysis.

tion was symmetrical, which indicated that there was no publication bias in our study (**Figure 3**).

## Discussion

Our results indicated fixation with volar locking plate had a better DASH scores than K-wire fixation at either time point. The possible explanations are that volar locking plates have superior biomechanical properties with impact stiffness supporting the physiological loads placed on the wrist joint [18]. However, there was no evidence of a significant difference in PRWE score between the treatment groups at 12 months.

Volar locking plate fixation led to an earlier recovery of grip strength at 3 months after operation. But there was no significant difference between the two groups at 12 months. Our data also indicated that volar locking plate restored better extension and supination at 3 months, while these differences were not present at 12 months.

According to our meta-analysis results, volar locking plate fixation and K-wire fixation have a similar rate of total complications. The result was consistent with the previous meta-analysis (Xie et al. 2013) comparing internal and external fixation of distal radius fractures [7].

Significant heterogeneity was observed in this study. The heterogeneity may be caused by the different technical proficiency of surgeons and different types of distal radius fractures. Since the sample size of some RCTs was small, patient age was considered as another source of heterogeneity. Previous study indicated that in patients sixty-five years of age or older, surgery could not give any improvement in terms of the range of motion, PRWE and DASH scores [19]. We are unable to perform a subgroup analysis for different age to identify possible source of heterogeneity, because none of the included study reported outcomes of volar locking plate fixation and K-wire fixation according to different age group.

There are some limitations in our study. Firstly, the study designs of the included trails were slightly different. For example, Rozental et al. study and Karantana et al. study reported outcome of range of motion at 3 months, while the others at 3 months. However, these trails were

analyzed together. The outcomes at 3 and 6 months were not analyzed in our meta-analysis, because the data were only given by a few studies. Secondly, the small sample size of the included trails may also increase the uncertainty of the results. Thirdly, we did not perform a pool analysis on activities of daily living and vocational function due to the limited number of trails.

In conclusion, the patient receiving fixation with volar locking plate for treatment of distal radius fractures achieved an early recovery of function compared to those with K-wire. However, there was no significant difference at 12 months. The number of complications between the two treatments was similar. The volar locking plate fixation may be of advantage to some patients requiring a faster recovery of function after surgery. In addition, large-size sample randomized controlled trials are needed to identify our findings.

## Acknowledgements

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## Disclosure of conflict of interest

None.

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## References

[1] Kotnis R, Waites MD, Fayomi O, Dega R. The use of a template to improve the management of distal radial fractures. Emerg Med J 2005; 22: 544-547.

[2] Chen NC, Jupiter JB. Management of distal radial fractures. J Bone Joint Surg Am 2007; 89: 2051-2062.

[3] Cooney WP 3rd, Linscheid RL, Dobyns JH. External pin fixation for unstable Colles' fractures. J Bone Joint Surg Am 1979; 61: 840-845.

[4] Horne G. A prospective randomized trial of external fixation and plaster cast immobilization in the treatment of distal radius fractures. J Orthop Trauma 1991; 5: 246.

[5] Kapoor H, Agarwal A, Dhaon BK. Displaced intra-articular fractures of distal radius: a comparative evaluation of results following closed reduction, external fixation and open reduction with internal fixation. Injury 2000; 31: 75-79.

[6] Downing ND, Karantana A. A revolution in the management of fractures of the distal radius? J Bone Joint Surg Br 2008; 90: 1271-1275.

[7] Xie X, Qin H, Shen L, Zhang C. Comparison of internal and external fixation of distal radius fractures. Acta Orthop 2013; 84: 286-291.

[8] Wei DH, Poolman RW, Bhandari M, Wolfe VM, Rosenwasser MP. External fixation versus internal fixation for unstable distal radius fractures: a systematic review and meta-analysis of comparative clinical trials. J Orthop Trauma 2012; 26: 386-394.

[9] Cui Z, Pan J, Yu B, Zhang K, Xiong X. Internal versus external fixation for unstable distal radius fractures: an up-to-date meta-analysis. Int Orthop 2011; 35: 1333-1341.

[10] Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, McQuay HJ. Assessing the quality of reports of randomized clinical trials: is blinding necessary? Control Clin Trials 1996; 17: 1-12.

[11] Tobias A. Assessing the influence of a single study in the meta-analysis estimate. Stata Tech Bul 1999; 15.

[12] Egol K, Walsh M, Tejwani N, McLaurin T, Wynn C, Paksima N. Bridging external fixation and supplementary Kirschner-wire fixation versus volar locked plating for unstable fractures of the distal radius: a randomised, prospective trial. J Bone Joint Surg Br 2008; 90: 1214-1221.

[13] Rozental TD, Blazar PE, Franko OI, Chacko AT, Earp BE, Day CS. Functional outcomes for unstable distal radial fractures treated with open reduction and internal fixation or closed reduction and percutaneous fixation. A prospective randomized trial. J Bone Joint Surg Am 2009; 91: 1837-1846.

[14] Wei DH, Raizman NM, Bottino CJ, Jobin CM, Strauch RJ, Rosenwasser MP. Unstable distal radial fractures treated with external fixation, a radial column plate, or a volar plate. A prospective randomized trial. J Bone Joint Surg Am 2009; 91: 1568-1577.

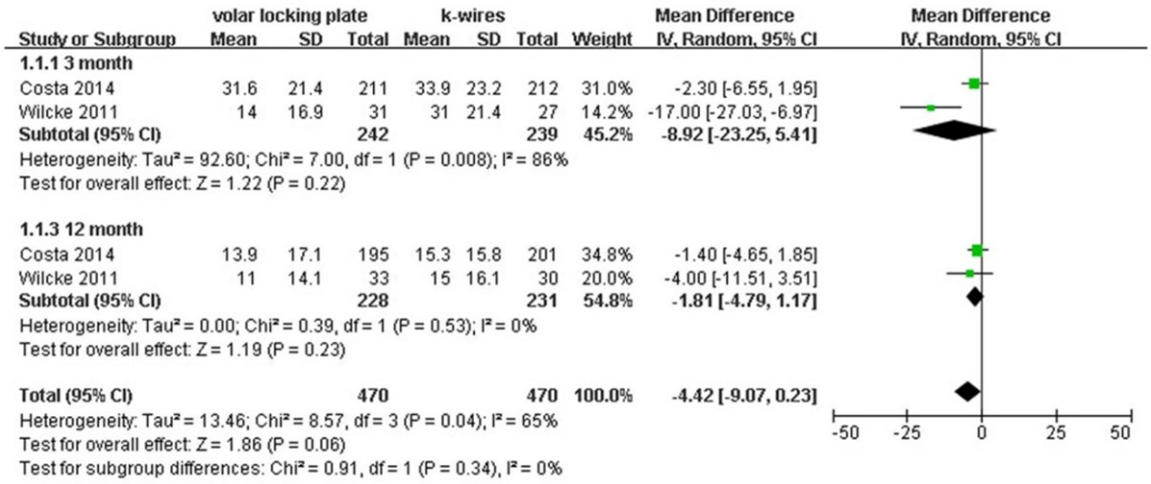
[15] Wilcke MK, Abbaszadegan H, Adolphson PY. Wrist function recovers more rapidly after volar locked plating than after external fixation but the outcomes are similar after 1 year. Acta Orthop 2011; 82: 76-81.

[16] Karantana A, Downing ND, Forward DP, Hatton M, Taylor AM, Scammell BE, Moran CG, Davis TR. Surgical treatment of distal radial fractures with a volar locking plate versus conventional percutaneous methods: a randomized controlled trial. J Bone Joint Surg Am 2013; 95: 1737-1744.

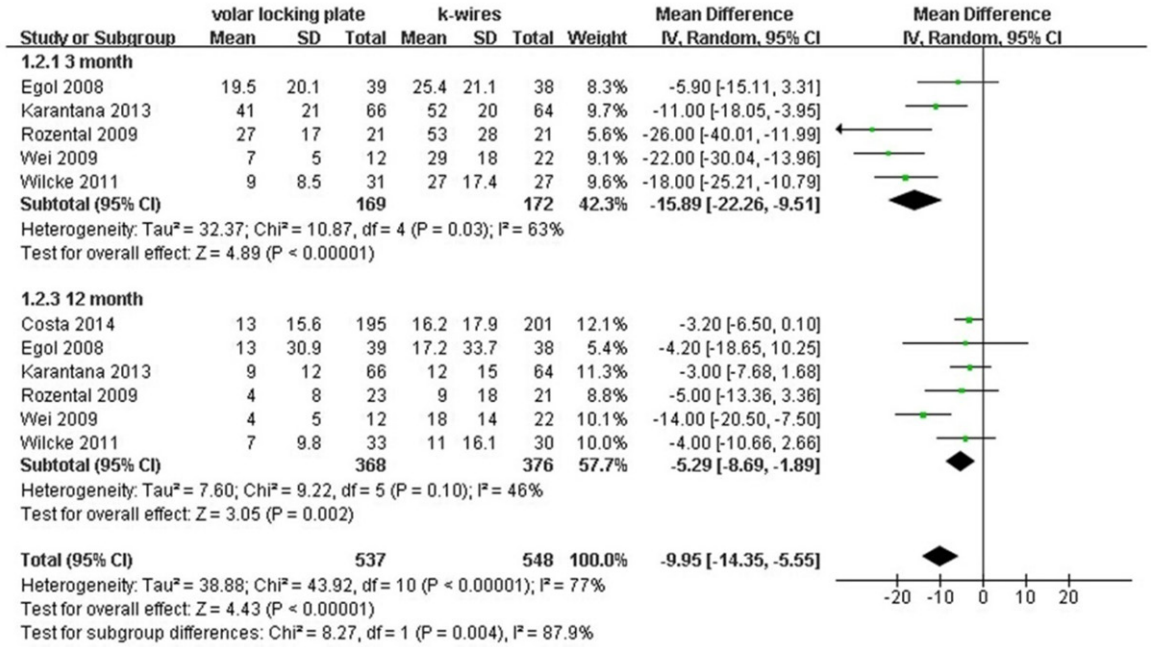
[17] Costa ML, Achten J, Parsons NR, Rangan A, Griffin D, Tubeuf S, Lamb SE; DRAFFT Study Group. Percutaneous fixation with Kirschner wires versus volar locking plate fixation in adults with dorsally displaced fracture of distal radius: randomised controlled trial. BMJ 2014; 349: g4807.

[18] Levin SM, Nelson CO, Botts JD, Teplitz GA, Kwon Y, Serra-Hsu F. Biomechanical evaluation of volar locking plates for distal radius fractures. Hand (N Y) 2008; 3: 55-60.

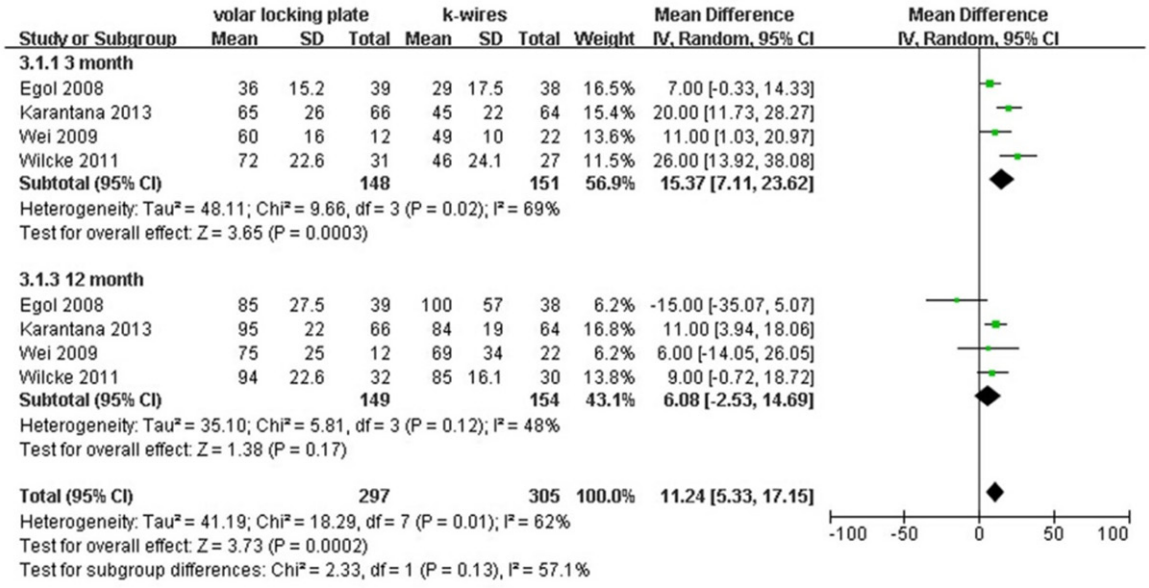
[19] Arora R, Lutz M, Deml C, Krappinger D, Haug L, Gabl M. A prospective randomized trial comparing nonoperative treatment with volar locking plate fixation for displaced and unstable distal radial fractures in patients sixty-five years of age and older. J Bone Joint Surg Am 2011; 93: 2146-2153.




**Supplementary Figure 1.** Comparison of volar locking plate and K-wire regarding the PRWE score.

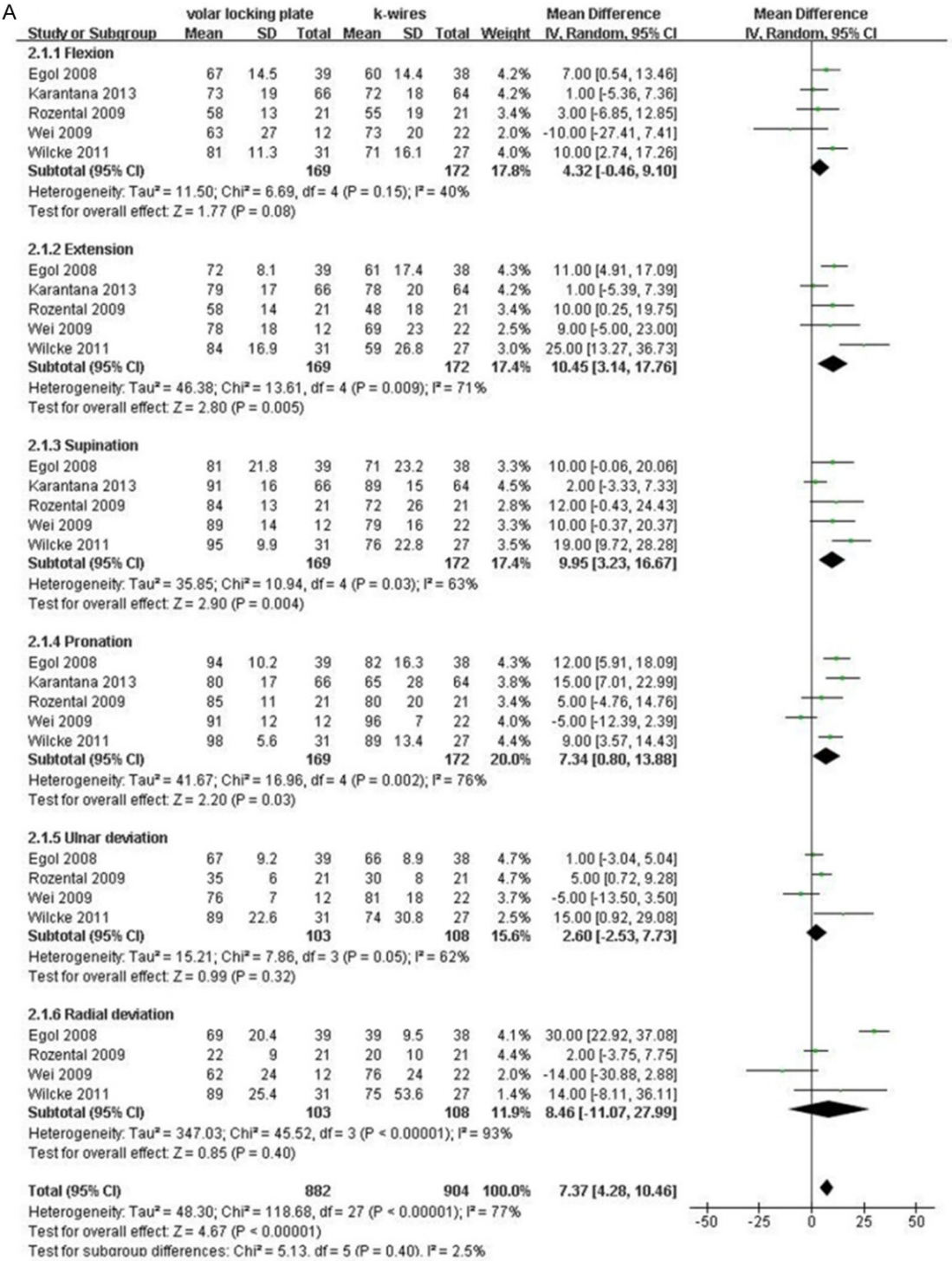


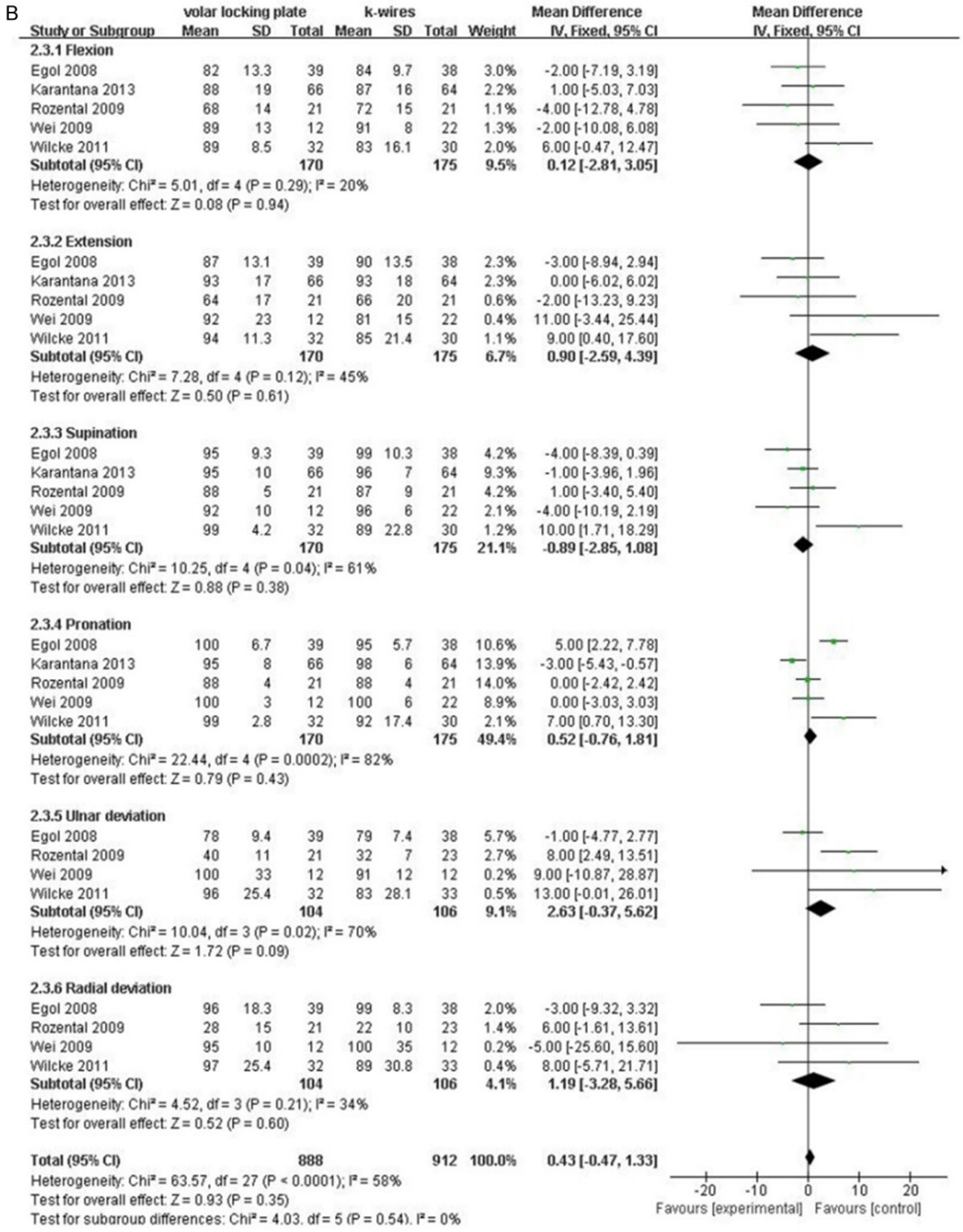

**Supplementary Figure 2.** Comparison of volar locking plate and K-wire regarding the DHAS score.




**Supplementary Figure 3.** Comparison of volar locking plate and K-wire regarding the grip strength.

A


volar locking plate
k-wires
Mean Difference
Mean Difference
Study or Subgroup Mean SD Total Mean SD Total Weight IV, Random, 95% CI
IV, Random, 95% CI
2.1.1 Flexion
Egol 2008 67 14.5 39 60 14.4 38 4.2% 7.00 [0.54, 13.46]
Karantana 2013 73 19 66 72 18 64 4.2% 1.00 [-5.36, 7.36]
Rozental 2009 58 13 21 55 19 21 3.4% 3.00 [-6.85, 12.85]
Wei 2009 63 27 12 73 20 22 2.0% -10.00 [-27.41, 7.41]
Wilcke 2011 81 11.3 31 71 16.1 27 4.0% 10.00 [2.74, 17.26]
Subtotal (95% CI) 169 172 17.8% 4.32 [-0.46, 9.10]
Heterogeneity: Tau² = 11.50; Chi² = 6.69, df = 4 (P = 0.15); I² = 40%
Test for overall effect: Z = 1.77 (P = 0.08)
2.1.2 Extension
Egol 2008 72 8.1 39 61 17.4 38 4.3% 11.00 [4.91, 17.09]
Karantana 2013 79 17 66 78 20 64 4.2% 1.00 [-5.39, 7.39]
Rozental 2009 58 14 21 48 18 21 3.4% 10.00 [0.25, 19.75]
Wei 2009 78 18 12 69 23 22 2.5% 9.00 [-5.00, 23.00]
Wilcke 2011 84 16.9 31 59 26.8 27 3.0% 25.00 [13.27, 36.73]
Subtotal (95% CI) 169 172 17.4% 10.45 [3.14, 17.76]
Heterogeneity: Tau² = 46.38; Chi² = 13.61, df = 4 (P = 0.009); I² = 71%
Test for overall effect: Z = 2.80 (P = 0.005)
2.1.3 Supination
Egol 2008 81 21.8 39 71 23.2 38 3.3% 10.00 [-0.06, 20.06]
Karantana 2013 91 16 66 89 15 64 4.5% 2.00 [-3.33, 7.33]
Rozental 2009 84 13 21 72 26 21 2.8% 12.00 [-0.43, 24.43]
Wei 2009 89 14 12 79 16 22 3.3% 10.00 [-0.37, 20.37]
Wilcke 2011 95 9.9 31 76 22.8 27 3.5% 19.00 [9.72, 28.28]
Subtotal (95% CI) 169 172 17.4% 9.95 [3.23, 16.67]
Heterogeneity: Tau² = 35.85; Chi² = 10.94, df = 4 (P = 0.03); I² = 63%
Test for overall effect: Z = 2.90 (P = 0.004)
2.1.4 Pronation
Egol 2008 94 10.2 39 82 16.3 38 4.3% 12.00 [5.91, 18.09]
Karantana 2013 80 17 66 65 28 64 3.8% 15.00 [7.01, 22.99]
Rozental 2009 85 11 21 80 20 21 3.4% 5.00 [-4.76, 14.76]
Wei 2009 91 12 12 96 7 22 4.0% -5.00 [-12.39, 2.39]
Wilcke 2011 98 5.6 31 89 13.4 27 4.4% 9.00 [3.57, 14.43]
Subtotal (95% CI) 169 172 20.0% 7.34 [0.80, 13.88]
Heterogeneity: Tau² = 41.67; Chi² = 16.96, df = 4 (P = 0.002); I² = 76%
Test for overall effect: Z = 2.20 (P = 0.03)
2.1.5 Ulnar deviation
Egol 2008 67 9.2 39 66 8.9 38 4.7% 1.00 [-3.04, 5.04]
Rozental 2009 35 6 21 30 8 21 4.7% 5.00 [0.72, 9.28]
Wei 2009 76 7 12 81 18 22 3.7% -5.00 [-13.50, 3.50]
Wilcke 2011 89 22.6 31 74 30.8 27 2.5% 15.00 [0.92, 29.08]
Subtotal (95% CI) 103 108 15.6% 2.60 [-2.53, 7.73]
Heterogeneity: Tau² = 15.21; Chi² = 7.86, df = 3 (P = 0.05); I² = 62%
Test for overall effect: Z = 0.99 (P = 0.32)
2.1.6 Radial deviation
Egol 2008 69 20.4 39 39 9.5 38 4.1% 30.00 [22.92, 37.08]
Rozental 2009 22 9 21 20 10 21 4.4% 2.00 [-3.75, 7.75]
Wei 2009 62 24 12 76 24 22 2.0% -14.00 [-30.88, 2.88]
Wilcke 2011 89 25.4 31 75 53.6 27 1.4% 14.00 [-8.11, 36.11]
Subtotal (95% CI) 103 108 11.9% 8.46 [-11.07, 27.99]
Heterogeneity: Tau² = 347.03; Chi² = 45.52, df = 3 (P < 0.00001); I² = 93%
Test for overall effect: Z = 0.85 (P = 0.40)
Total (95% CI) 882 904 100.0% 7.37 [4.28, 10.46]
Heterogeneity: Tau² = 48.30; Chi² = 118.68, df = 27 (P < 0.00001); I² = 77%
Test for overall effect: Z = 4.67 (P < 0.00001)
Test for subgroup differences: Chi² = 5.13, df = 5 (P = 0.40), I² = 2.5%
-50 -25 0 25 50




**Supplementary Figure 4.** Comparison of the effects of volar locking plate and K-wire on range of motion. A. 3 months; B. 12 months.