Volar Locking Plate Fixation Versus Closed Reduction for Distal Radial Fractures in Adults

A Systematic Review and Meta-Analysis

Andrew Lawson, BAppSc(Phty), MPH

Michael Na, MBBS

Justine M. Naylor, BAppSc(Phty), PhD

Adriane M. Lewin, MSc(Epidemiology)

Ian A. Harris, MBBS, MMed(ClinEpi), PhD

Investigation performed at the Whitlam Orthopaedic Research Centre, Ingham Institute for Applied Medical Research, South Western Sydney Clinical School, University of New South Wales (UNSW) Australia, Sydney, New South Wales, Australia

Abstract

Background: Distal radial fractures in adults are common, representing a substantial burden to patients and health systems. The 2 main treatments are closed reduction and cast immobilization (CR) and volar locking plate (VLP) fixation. Our primary aim was to determine if VLP fixation leads to better patient-reported pain and function at 12 months compared with CR.

Methods: We searched systematically for randomized controlled trials (RCTs) comparing outcomes of VLP fixation with CR for the treatment of distal radial fractures in adults. The Cochrane Collaboration risk-of-bias tool was used to assess the methodological quality of each study. Meta-analyses of patient-reported outcomes, clinical outcomes, and complications were performed. Key findings were assessed using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach.

Results: A total of 8 RCTs (810 participants) were eligible for inclusion. Based on moderate-certainty evidence, no clinically important differences in patient-reported pain and function were found: although the mean difference (MD) in the Disabilities of the Arm, Shoulder and Hand (DASH) score at 12 months was 4.1 points (95% confidence interval [CI], 1.2 to 7.0 points) in favor of VLP fixation, this was well below the minimum clinically important difference of 10 points. There was low-certainty evidence that VLP fixation led to better Patient-Rated Wrist Evaluation (PRWE) scores at 12 months (MD, 6.9 points; 95% CI, −0.6 to 14.3 points) and better DASH scores at 24 months (MD, 8.9 points; 95% CI, 5.8 to 12.1 points) but again, these differences were not clinically important. There was very low or low-certainty evidence that VLP fixation provided better long-term radiographic outcomes, including palmar tilt (MD, 6.5°; 95% CI, 2.8° to 10.1°), radial inclination (MD, 3.4°; 95% CI, 2.5° to 4.3°), and ulnar variance (MD, 0.7 mm; 95% CI, −0.8 to 2.1 mm).

Conclusions: There were no clinically important differences between treatments with respect to patient-reported pain and function at 12 months post-treatment, even though VLP fixation resulted in better fracture alignment than CR.

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Level of Evidence: Therapeutic Level II. See Instructions for Authors for a complete description of levels of evidence.

Distal radial fractures are among the most common fractures seen in hospital emergency departments[1], representing a burden to patients and a large cost to health systems[2,3], and their incidence is rising[1-3]. The 2 most common treatments for distal radial fractures are nonoperative, using closed reduction and cast immobilization (CR), and operative, using open reduction and internal fixation with a volar locking plate (VLP). While operative treatment offers early clinical benefits, including better fracture realignment and earlier return to function[4-8], longer-term outcomes remain unclear. In the last 2 decades there has been a rise in the use of VLP fixation[8-11], leading to considerable practice variation in the treatment of distal radial fractures[10,12-15], with treatment determined by patient factors including age, sex, and geographic region[10,12] as well as surgeon factors including preference, level of experience, and subspecialty[13-15].

Earlier systematic reviews on this topic are either out of date or rely on a mixture of randomized and non-randomized studies with few included randomized controlled trials (RCTs)[4,7,8,16]. These reviews are broad in scope; compare numerous, predominantly surgical, treatments; and highlight a need for good-quality evidence supported by RCT findings. Consequently, clinical practice guidelines produced by professional organizations[17-20] lack detail regarding VLP fixation versus CR. As a result, the choice of treatment is influenced as much by surgeon preference or patient expectations as by good-quality evidence and clinical guidelines[15]. Therefore, there is strong potential to strengthen the evidence base and thereby influence practice and shared decision-making by comparing the 2 most common treatments.

The primary objective of this review was to determine if VLP fixation, compared with CR, leads to significantly better patient-reported pain and function at 12 months post-treatment. Secondary objectives were to compare patient-reported outcomes at other time frames as well as clinical outcomes including radiographic outcomes, grip strength, joint range of motion, and post-treatment complications.

Materials and Methods

This review uses methods described in the Cochrane Handbook, version 6[21], and is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[22]. The assessment and presentation of key findings were conducted according to the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) guidelines[23], using GRADE-pro Software (McMaster University and Evidence Prime, https://gradepro.org).

Search Strategy

A search of MEDLINE (1950 to present), Embase (1946 to current), the Cumulative Index to Nursing and Allied Health Literature (CINAHL, 1982 to present), and the Cochrane Central Register of Controlled Trials (CENTRAL) was conducted on June 20, 2019. An example of the search strategy, for MEDLINE, is given in the Appendix. All literature was considered regardless of language or publication status. Reference lists of identified reports and articles were searched for additional studies.

Identification and Selection of Studies

Studies were included if (1) the participants were adults (≥18 years old) and had undergone treatment for a distal radial fracture, (2) the intervention was VLP fixation, (3) the comparator was CR and cast or splint immobilization, (4) the outcomes were clinical and patient-reported outcomes, and (5) the treatment allocation was prospectively randomized.

Data Extraction

Two review authors (M.N. and A. Lawson) independently reviewed the articles for suitability, initially by title and abstract and then by full text as required. Disagreements were resolved by discussion. The same 2 authors each extracted data from the selected studies. If full data sets were not available in the published reports, the authors of the report were contacted for further information. Two studies provided unpublished data[24,25], which were included in the analysis.

Outcomes

Treatment outcomes were categorized into 3 groups: patient-reported outcomes, clinical outcomes, and treatment complications. The primary outcome was patient-reported pain and function at 12 months. Secondary outcomes were patient-reported pain and function at other time points, health-related quality of life (HRQoL), radiographic measurements, wrist joint range of motion, grip strength, and complications.

Radiographic outcomes were grouped into 2 time frames: post-treatment, which included post-procedure radiographs, and 3 to 12 months combined. While fracture alignment may change in the post-treatment period, it was unlikely to change from 3 months onward. For other clinical outcomes and for patient-reported outcomes, data were extracted for 3-month, 12-month, and, if available, 24-month time points.

Instruments

The Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire is a 30-item patient-reported measure of disability and symptoms of the upper limb, scored from 0 to 100, with higher scores indicating poorer outcomes[26]. The minimum clinically important difference (MCID) for the DASH has been reported at 10 points[27]. The Patient-Rated Wrist Evaluation (PRWE) questionnaire is a 15-item patient-reported measure of pain and function, specific to the wrist, scored between 0 to 100, with higher scores indicating poorer outcomes[28]. A range of MCIDs has been reported for the PRWE, but for this review, the MCID of 11.5 points reported for patients with a distal radial fracture[29] was used. Both instruments have been validated for use in distal radial fractures[30]. We performed a meta-analysis of DASH and PRWE outcomes at 3 and 12 months, and DASH outcomes at 24 months.

The EuroQol-5 Dimension, 5 Level (EQ-5D-5L) tool is a 5-dimension patient-reported measure of HRQoL. The tool produces 7 outcomes: 5 categorical scores (1 for each dimension), a utility index score (EQ-UI), and a separate visual analog scale (VAS) score (EQ-VAS). The maximum EQ-UI score is 1, representing full health. Zero represents a health state equivalent to death, although the index can also take negative values that indicate subjective health states worse than death. EQ-VAS scores range from 0 to 100, with 0 equating to the worst and 100 equating to the best health state imaginable[31].

Clinical Outcomes

Clinical outcomes included radiographic measures, wrist joint range of motion, and grip strength. Radiographic measures included palmar tilt and radial inclination, measured in degrees, and ulnar variance and articular step-off, measured in millimeters. This selection was supported by a structured review of literature regarding radiographic measures of distal radial fractures[32]. Where the normative value was not zero, radiographic outcomes were adjusted using the normative value for each measure. For example, using the normative value of volar or palmar tilt of 11°[33], reported values were subtracted from 11° such that adjusted values closer to zero indicated better radiographic outcomes. A normative radial inclination value of 23°[33] was used.

Range-of-motion outcomes including flexion, extension, radial deviation, ulnar deviation, supination, and pronation were reported in absolute terms in degrees. Grip strength outcomes were reported in absolute terms in kilograms. The MCID for grip strength in patients with a distal radial fracture at 12 months post-treatment has been reported as 6.5 kg[34].

Complications

Complication frequency was reported by treatment group, and the risk difference (RD) was reported between the groups. Complications were grouped into themes: malunion or loss of reduction, tendinitis/tendon rupture, carpal tunnel syndrome, complex regional pain syndrome, infection, nerve lesion, osteoarthritis, finger stiffness, and removal or failure of hardware.

Assessment of Study Quality and Level of Evidence

Two reviewers (A.M.L. and A. Lawson) assessed study quality using the Cochrane Collaboration risk-of-bias tool[35]. The tool assesses selection, performance, detection, attrition, and reporting biases. We attempted to contact authors of included studies if further information was required to clarify the risk of bias. The same 2 reviewers assessed the quality and strength of evidence using GRADE guidelines[23] for patient-reported function at 12 months (primary outcome) and 24 months, HRQoL at 12 months, and radiographic outcomes (palmar tilt, radial inclination, and ulnar variance) at 3 to 12 months. Disagreements were resolved by discussion.

Study quality was also assessed using the Physiotherapy Evidence Database (PEDro) scale[36,37] which produces a quantitative assessment of bias as a score out of 10, with higher scores indicating higher methodological quality.

Publication Bias

Funnel plots were used to assess publication bias for outcomes included in the GRADE assessment only.

Statistical Analysis

Review Manager software (RevMan, version 5.3; Cochrane Collaboration) was employed for analysis, using a random-effects model. Effect sizes were presented for continuous outcomes as mean differences (MDs) with 95% confidence intervals (CIs), and for categorical data as RDs with 95% CIs. For all meta-analyzed outcomes, effect sizes were presented using forest plots and assessed heterogeneity is presented using I^2 values. Certain results (range of motion, grip strength, and some ulnar variance values) were converted so that a negative MD favored surgical treatment and a positive MD favored nonsurgical treatment for every outcome. In each case that we converted values from negative to positive or from positive to negative for this purpose, the absolute value of the MD was maintained and the sign conversion was noted in the footnotes of the forest plot.

A sensitivity analysis restricted to studies that included participants with a mean age of ≥60 years was conducted to assess whether the results remained robust in an older population.

Results

Study Selection and Characteristics of the Study Population

The search returned 1,759 records. After removal of 710 duplicates, we conducted title and abstract assessment of 1,049 records, excluded 1,024 articles, and conducted full-text assessment of the remaining 25. After the final review, 8 articles[24,25,38-43] were eligible for qualitative synthesis and meta-analysis (Fig. 1). One study[40] included 3 treatment arms but only outcomes from the VLP fixation and CR treatment arms were considered here. The 8 included studies randomized 792 participants, 391 (49.4%) allocated to VLP fixation and 401 (50.6%) allocated to CR. Five studies specifically recruited older participants[25,38,39,41,42] (Table I).

Assessment of Study Quality

The Cochrane risk-of-bias tool indicated high risk of performance bias for all included studies, given that treatment allocation was not blinded (Table II; see also Appendix 2.1). The risk of detection bias was high or unclear in all included studies, given the difficulties in blinding outcome

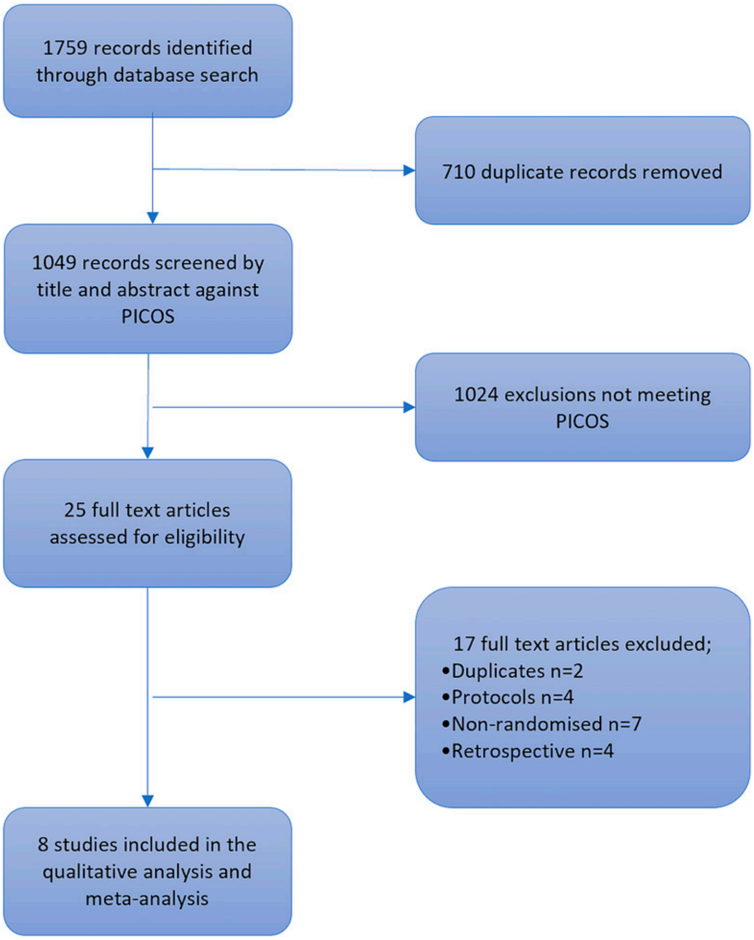

Fig. 1
Flow diagram for selection of studies. PICOS = population, intervention, comparator, outcome, study type.

assessment. There was high risk of attrition bias in 4 studies[38-40,42], due to low rates of follow-up (≤85%) or differential loss to follow-up between treatment groups. The risk of selection bias was high in only 1 study[43]. The risk of publication bias was low; funnel plots were symmetrical (see Appendix 2.2) and inspection of forest plots (Figs. 2, 3, and 4; see also Appendix 3) revealed only 1 aberrant outcome (for ulnar variance). The PEDro scores for the included studies ranged from 4 to 7 out of a possible total of 10, with 10 indicating the highest methodological quality (see Appendix 2.3).

Patient-Reported Outcomes

Patient-Reported Pain and Function

Based on moderate-certainty evidence for DASH scores and low-certainty evidence for PRWE scores, no clinically important between-group differences were found at 12 months post-treatment; patients who had undergone VLP fixation had a mean DASH score that was 4.1 points better (95% CI, 1.2 to 7 points; $p = 0.005$) and a mean PRWE score that was 6.9 points better (95% CI, −0.6 to 14.3 points) than those who had undergone CR (Fig. 5). These differences were below the respective reported MCIDs of 10 and 11.5 points. Based on low-certainty evidence, there were no clinically important differences between groups at 24 months; although the DASH score was a mean of 8.9 points (95% CI, 5.8 to 12.1 points; $p < 0.00001$) higher for the VLP group compared with the CR group, this value was again below the reported MCID. While PRWE scores at 24 months were better following VLP fixation by a clinically important difference of 13 points, this result must be interpreted with caution as it is based on only 1 study[41], thus precluding meta-analysis for this outcome. At 3 months, patient-reported pain and function favored VLP fixation although between-group differences were small and in the case of the DASH score, unlikely to be clinically meaningful; the MD was 7.2 points (95% CI, 4 to 10.5 points, $p < 0.0001$) for the DASH and 15.1 points (95% CI, 8.4 to 21.7 points; $p < 0.0001$) for the PRWE. Generally, patient-reported outcomes were homogenous, with low I^2 values (Fig. 2).

Quality of Life

There was virtually no difference in EQ-UI scores between groups at 3 and 12 months post-surgery. The mean EQ-UI score at 3 months was 0.04 (95% CI, 0 to 0.08; $p = 0.08$) better following VLP fixation compared with CR. At 12 months (the primary end point), the score difference between treatment groups was

TABLE I Summary of Included Studies*

Study, Location	Total Participants (Nonsurg./Surg.), Mean Age	Intervention	Comparator	Outcomes	Time Points
Arora (2011)[38], Austria	73 (37/36), 77 and 76 yr	Initial nonsurgical treatment (CR and plaster cast). Recruited to study at 1 wk. Surgical treatment within 14 days after injury, immobilized for 2-3 wk, then physiotherapy commenced	Initial nonsurgical treatment (CR and plaster cast). Recruited to study at 1 wk. Immobilized in short-arm cast in neutral position for 5 wk, then physiotherapy commenced	• Primary: PRWE (MCID = 10 points) • Clinical: radiographic measures, complications, wrist range of motion, grip strength, pain on VAS • Patient-reported: DASH, PRWE	6 and 12 wk, 6 and 12 mo post-fracture
Bartl (2014)[39], Germany	185 (94/91) with AO/OTA type 23C, 74 and 75 yr	Initial nonsurgical treatment (CR and plaster cast), then ORIF with VLP. Physiotherapy commenced 2 wk after surgery	Initial nonsurgical treatment (CR and plaster cast), immobilized in short-arm cast for 6 wk, then physiotherapy commenced	• Primary: SF-36 PCS at 12 mo (MCID = 2.5 points) • Clinical: radiographic measures, complications, wrist range of motion • Patient reported: DASH, PRWE, SF-36, EQ-5D	3 and 12 mo
Kapoor (2000)[40], India	90 (33/28 external fixation and 29 ORIF), 39 yr	ORIF using Kirschner wires and/or T-plates, then immobilized for 2 wk. Active exercises and wax bath	CR, then immobilized in plaster cast for 6-7 wk. In cases of inadequate reduction on radiographs at 1 wk after CR and casting, an additional CR attempt was made	• Primary: not stated • Clinical: grip strength, wrist range of motion, complications, Gartland and Werley score • Patient-reported: none	Not stated; mean follow-up, 4 yr
Martinez-Mendez (2018)[41], Spain	97 (47/50) with AO/OTA type 23C, 70 and 67 yr	Initial nonsurgical treatment performed in ED, then ORIF with VLP, with allograft used as required. Immobilized in cast for 1 wk, then physiotherapy commenced	Initial nonsurgical treatment performed in ED. Continued cast immobilization to 6 wk, then physiotherapy commenced	• Primary: PRWE at 24 mo (MCID = 14 points) • Clinical: radiographic measures, complications, wrist range of motion, pain VAS, grip strength. • Patient-reported: DASH, PRWE	2 and 6 wk, 6, 12 and >24 mo; only data from >24-mo follow-up were reported
Mulders (2019)[24], Netherlands	92 (44/48) with AO/OTA type 23A2 and 23A3, 60 yr	Initial nonsurgical treatment performed in ED. Immobilized in splint for 1 wk, then ORIF with VLP. No postop. immobilization, activity commenced as pain allowed	Initial nonsurgical treatment performed in ED. Immobilized in splint for 1 wk, then changed to short-arm cast and immobilized for another 4-5 wk. Home exercises commenced after cast removal	• Primary: DASH at 12 mo (MCID = 15 points) • Clinical: complications, wrist range of motion at 6 wk and 3, 6, and 12 mo • Patient-reported: DASH and PRWE at 6 wk and 3, 6, and 12 mo	1, 3, and 6 wk, 3, 6, and 12 mo
Saving (2019)[42], Sweden	140 (72/68), 78 and 80 yr	Initial nonsurgical treatment performed in ED. Immobilized in short-arm cast, then ORIF within 14 days. Immobilized in short-arm cast for 2 wk, then occupational therapy commenced	Initial nonsurgical treatment performed in ED. Immobilized in short-arm cast for 4-5 wk, then occupational therapy commenced	• Primary: DASH, PRWE (time point not stated) • Clinical: grip strength, wrist range of motion, radiographic measures at 3 and 12 mo, complications at 12 mo • Patient-reported: DASH, PRWE, EQ-5D at 3 and 12 mo	3 and 12 mo; radiographic results also included baseline and post-treatment
Sharma (2014)[43], India	64 (32/32) with AO/OTA 23B and 23C, 48 and 52 yr	ORIF using VLP, immobilized in below-elbow wrist brace for 1 wk, then formal outpatient physiotherapy commenced	CR, immobilized in above-elbow plaster cast for 4 wk, then formal outpatient physiotherapy commenced	• Primary: not stated • Clinical: wrist range of motion, radiographic outcomes, Gartland and Werley scores • Patient-reported: DASH	6 wk and 3, 6, 12, 18, and 24 mo
Sirniö (2019)[25], Finland	80 (42/38) with AO/OTA 23C3, 63 yr	Initial nonsurgical treatment performed in ED. Immobilized in splint, then ORIF using VLP performed within 1 wk of injury. Immobilized for 10 days, then active exercises commenced	Initial nonsurgical treatment performed in ED. Immobilized in splint for 1 wk, then changed to short-arm cast and immobilized for another 4-5 wk. Home exercises commenced after cast removal	• Primary: DASH at 24 mo (MCID = 15 points) • Clinical: complications, wrist range of motion, radiographic measures, grip strength • Patient-reported: DASH	3, 6, 12, and 24 mo

*All studies were RCTs. SF-36 PCS = Short Form-36 Physical Component Summary, ORIF = open reduction and internal fixation, and ED = emergency department.

close to equivocal (MD = 0.01; 95% CI, −0.04 to 0.06; p = 0.67), based on low-quality evidence (Fig. 5). EQ-UI scores were homogenous, with $I^2 = 0\%$ at 3 and 12-month timeframes (Fig. 3).

Clinical Outcomes

Radiographic Outcomes

Generally, radiographic outcomes were better for VLP fixation, although differences between groups were small to infinitesimal for all measures at all time points. Radiographic data included time frames of 3[39] to 12 months[24,25,38,41-43]. Based on very low-certainty evidence, palmar tilt for the VLP fixation group was a mean of 4.1°

(95% CI, −1.2° to 9.3°) closer to the normative value of 11° immediately post-treatment, and a mean of 6.5° (95% CI, 2.8° to 10.1°; $p = 0.0001$) closer at 3 to 12 months, than for the CR group.

Likewise, based on low-certainty evidence, radial inclination outcomes were slightly better with VLP fixation, with an MD of 2.8° (95% CI, 1.5° to 4.2°; $p < 0.0001$) immediately post-treatment and 3.4° (95% CI, 2.5° to 4.3°; $p < 0.00001$) at 3 to 12 months post-treatment. Based on low-certainty evidence, ulnar variance was better in the VLP group by a mean of 0.8 mm (95% CI, 0.3 to 1.3 mm; $p = 0.0008$) immediately post-treatment and by a mean of 0.7 mm (95% CI, −0.8 to 2.1 mm; $p = 0.38$) at 3 to 12 months post-treatment. Articular step-off outcomes were better at 3 to 12 months with VLP fixation by a mean of 0.5 mm (95% CI, 0.1 to 0.9 mm; $p = 0.009$). Apart from articular step-off ($I^2 = 0\%$), radiographic outcomes had substantial heterogeneity ($I^2 = 52\%$ to 94%; Figs. 4 and 6).

Grip Strength

Assessed against an MCID of 6.5 kg, differences between VLP fixation and CR were not clinically important. Grip strength was greater for the VLP group by 3.1 kg (95% CI, 1.5 to 4.7 kg; $p = 0.0002$) at 3 months, which decreased to 2 kg (95% CI, −0.3 to 4.4 kg; $p = 0.09$) by 12 months. Outcomes had low to moderate heterogeneity ($I^2 = 0\%$ to 43%; see Appendix 3.1).

Wrist Range of Motion

Range-of-motion outcomes were generally better following VLP fixation, although between-group differences were small. At 3 months, surgical treatment was associated with a mean of 5.6° (95% CI, 1.2° to 9.9°; $p = 0.01$) greater extension, 6.3° (95% CI, 0.6° to 11°; $p = 0.03$) greater flexion, 2.5° (95% CI, 0.4° to 4.6°; $p = 0.02$) greater pronation, and 3.1° (95% CI, 1° to 5.2°; $p = 0.005$) greater ulnar deviation compared with CR. At 12 months, VLP fixation led to a mean of 2.3° (95% CI, 0.3° to 5.6°; $p = 0.03$) greater ulnar deviation. Other range-of-motion outcomes were generally better following surgical treatment but differences were small and decreased over time (see Appendix 3.2).

Complications

Overall, there were 97 complications reported following VLP fixation (n = 391 participants) and 194 recorded following CR (n = 401 participants). The incidence of malunion or loss of reduction was lower in the VLP fixation group (5 of 255) than in the CR group (83 of 274), with an RD of −0.28 (95% CI, −0.45 to −0.12; $p = 0.0008$). The incidence of finger stiffness was also lower in the VLP fixation group (1 of 61) compared with the CR group (14 of 65), with an RD of −0.19 (95% CI, −0.36 to −0.03; $p = 0.02$). The incidence of carpal tunnel syndrome was lower for VLP fixation (6 of 316) than CR (20 of 330), with an RD of −0.03 (95% CI, −0.07 to 0.01; $p = 0.1$). Similarly, complex regional pain syndrome was less common in the VLP group (3 of 272) than in the CR group (13 of 277) (RD = −0.021; 95% CI, −0.05 to 0; $p = 0.06$), and the incidence of osteoarthritis was lower with surgical treatment (27 of 197) than with nonsurgical treatment (46 of 191) (RD = −0.08; 95% CI, −0.22 to 0.05; $p = 0.2$).

Conversely, VLP fixation was associated with a higher incidence of implant removal or failure of hardware (19 of 163 compared with 2 of 168), with an RD of 0.08 (95% CI, 0.02 to 0.15; $p = 0.007$). Similarly, tendinitis or tendon rupture was more common with VLP fixation (21 of 337) than CR (7 of 344), with an RD of 0.03 (95% CI, −0.01 to 0.08; $p = 0.15$), and infection was more common with VLP fixation (7 of 333) than CR treatment (1 of 342), with an RD of 0.01 (95% CI, −0.01 to 0.03; $p = 0.21$). The pooled risk of nerve lesions was equivocal (RD = 0; 95% CI, −0.05 to 0.05; $p = 0.98$; see Appendix 3.3), with rates of 8 of 190 for surgical treatment and 8 of 200 for nonsurgical treatment.

Sensitivity Analysis

Six of the 8 included studies had participants with a mean age of ≥60

TABLE II Summary of Cochrane Collaboration Risk of Bias

	Risk of Bias						
Study	Random Sequence Generation (Selection Bias)	Allocation Concealment (Selection Bias)	Blinding of Participants and Personnel (Performance Bias)	Blinding of Outcome Assessment (Detection Bias)	Incomplete Outcome Data (Attrition Bias)	Selective Reporting (Reporting Bias)	Other Biases
Arora[38]	Unclear	Low	High	High	High	Low	Low
Bartl[39]	Low	Low	High	Unclear	High	Low	Low
Kapoor[40]	Unclear	Unclear	High	Unclear	High	High	Low
Martinez-Mendez[41]	Low	Low	High	Unclear	Low	Unclear	Low
Mulders[24]	Low	Unclear	High	Unclear	Low	Low	Low
Saving[42]	Low	Low	High	High	High	Low	Low
Sharma[43]	High	High	High	Unclear	Low	Low	Low
Sirniö[25]	Low	Low	High	Unclear	Unclear	Low	Low

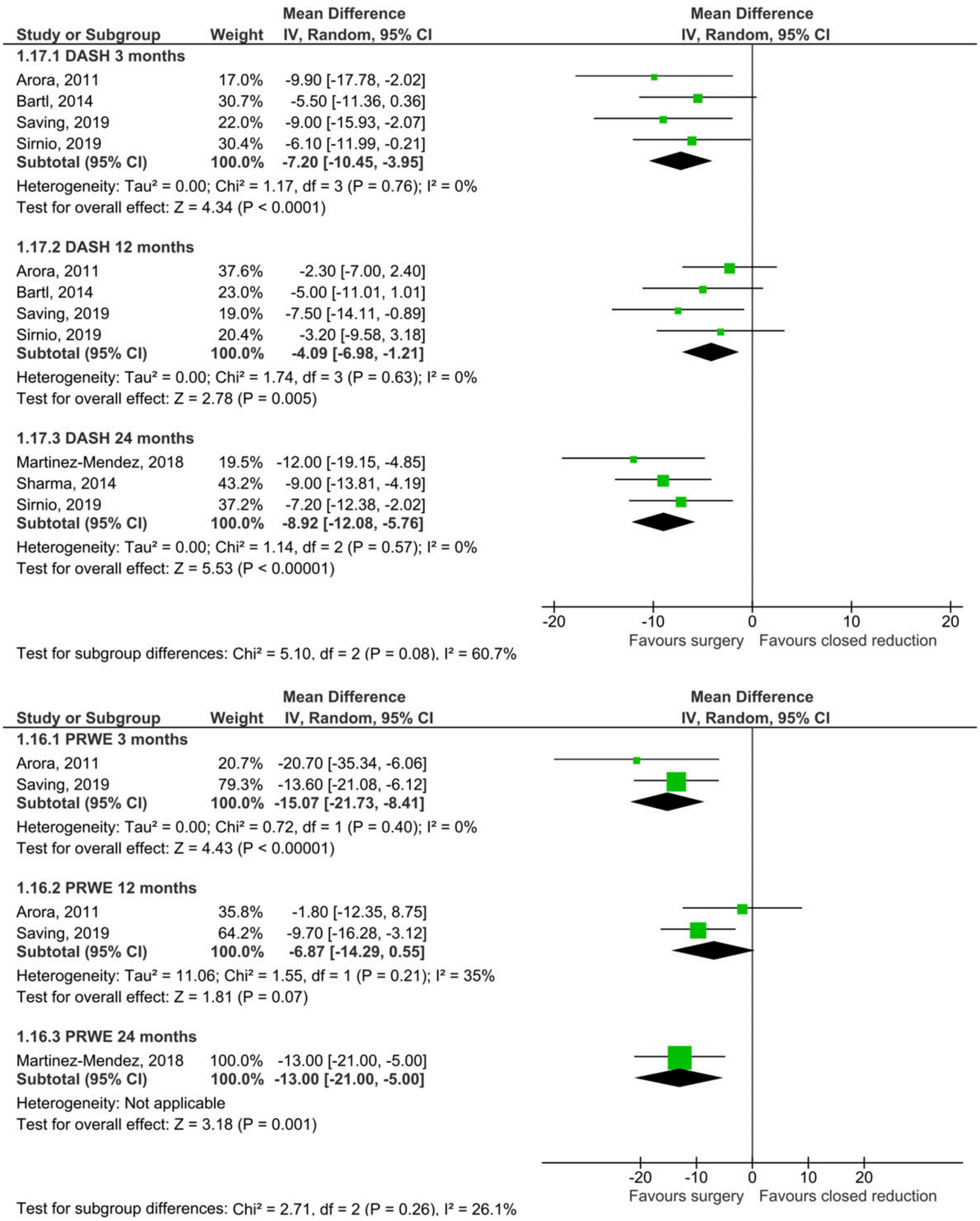

Fig. 2

Forest plot for patient-reported pain and function, including DASH (Disabilities of the Arm, Shoulder and Hand questionnaire) and PRWE (Patient-Rated Wrist Evaluation). IV = inverse variance, and df = degrees of freedom.

years[24,25,38,39,41,42]. No studies that included younger participants reported DASH or PRWE data at 12 months (the primary outcome in this analysis). When the analysis was restricted to only older participants, the MD for patient-reported function (DASH) at 24 months was unchanged at 8.9 points (95% CI, 4.4 to 13.5 points; p = 0.0001), but the MDs for 2 radiographic outcomes increased: palmar tilt increased from 6.5° to 8.1° (95% CI, 3.4° to 12.8°; p = 0.0008), radial inclination increased from 3.4° to 3.8° (95% CI, 2.5° to 5.1°; p < 0.0001), while ulnar variance

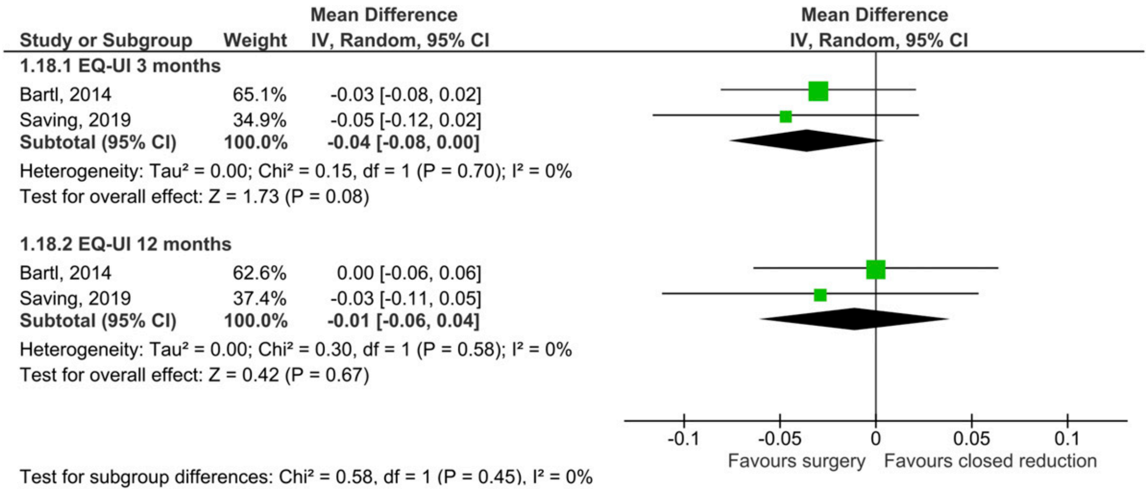

Fig. 3

Forest plot for quality of life (EQ-UI [EuroQol Utility Index score]). IV = inverse variance, and df = degrees of freedom.

remained unchanged at 0.7 mm (95% CI, −0.8 to 2.1 mm; p = 0.38) (see Appendix 4.1).

Discussion

Main Findings

For treatment of distal radial fractures in adult patients, no clinically important differences were found between volar locking plate fixation and closed reduction for the primary outcome, patient-reported pain and function at 12 months, despite VLP fixation providing better fracture alignment than CR. These conclusions were based on low to moderate-certainty evidence for patient-reported outcomes and very low to low-certainty evidence for radiographic outcomes. No clinically important between-group differences were found in grip strength, differences in range of motion were small and decreased over time, and quality-of-life outcomes were equivocal at 12 months. Complication rates were generally lower for VLP fixation than for CR.

Comparison with Other Reviews and Guidelines

Five published systematic reviews based on a mixture of observational studies and RCTs concluded that surgical treatment (all types, including VLP fixation), compared with nonsurgical treatment, was associated with better fracture alignment[4,7-9,16], a finding replicated in our study. A review published in 2003[16] found insufficient evidence to determine if surgical treatment was associated with any other clinical benefits. Later reviews[4,8,9] reported no clinically important differences in patient-reported function between treatment groups, again reflecting our findings. Three reviews[4,7,9] found significantly lower rates of major complications with nonsurgical treatment of older patients. Another review reported a >10-fold cost differential between VLP fixation and CR treatment[8]. A 2020 review[9] concluded that "operative treatment might be more effective" despite there being no clinically important difference in primary outcomes (DASH and complications).

Clinical practice guidelines regarding the treatment of distal radial fractures provide scant guidance concerning VLP fixation versus CR[17-20]. Earlier guidelines[17,18] lacked evidence to make specific recommendations regarding these 2 treatment options. Later guidelines made recommendations based largely on evidence from 2 RCTs[38,39]. A Norwegian guideline made a strong recommendation for operative treatment in adults and a weak recommendation for operative treatment in patients aged ≥65 years[19]. In contrast, a British guideline made no recommendation for patients <65 years old and recommended CR as the primary treatment option after careful consideration of patient characteristics[20].

Two recent systematic reviews[8,9] comparing surgical treatment (all forms) with nonsurgical treatment both found no clear benefit in functional outcomes from surgical treatment in older patients. The latest review[9] was most comparable with our study in that all adult patients were included, not just the elderly. Like the current study, it found no clinically important difference in patient-reported function at 12 months; however, despite finding no differences in the primary outcomes (DASH and complications) that were clinically important according to the MCIDs used in our study, Ochen et al. did not consider any MCID values when they concluded that "operative treatment might be more effective."[9]

Future Considerations

There are at least 2 RCTs currently underway that compare VLP fixation with CR (CROSSFIRE[44] and VIPAR-C[45]) and would satisfy our inclusion criteria, so an update may be warranted once those studies have published results. Our literature search also identified 2 protocols for systematic reviews comparing VLP fixation with nonsurgical treatment for distal radial fractures; 1 was later withdrawn from the

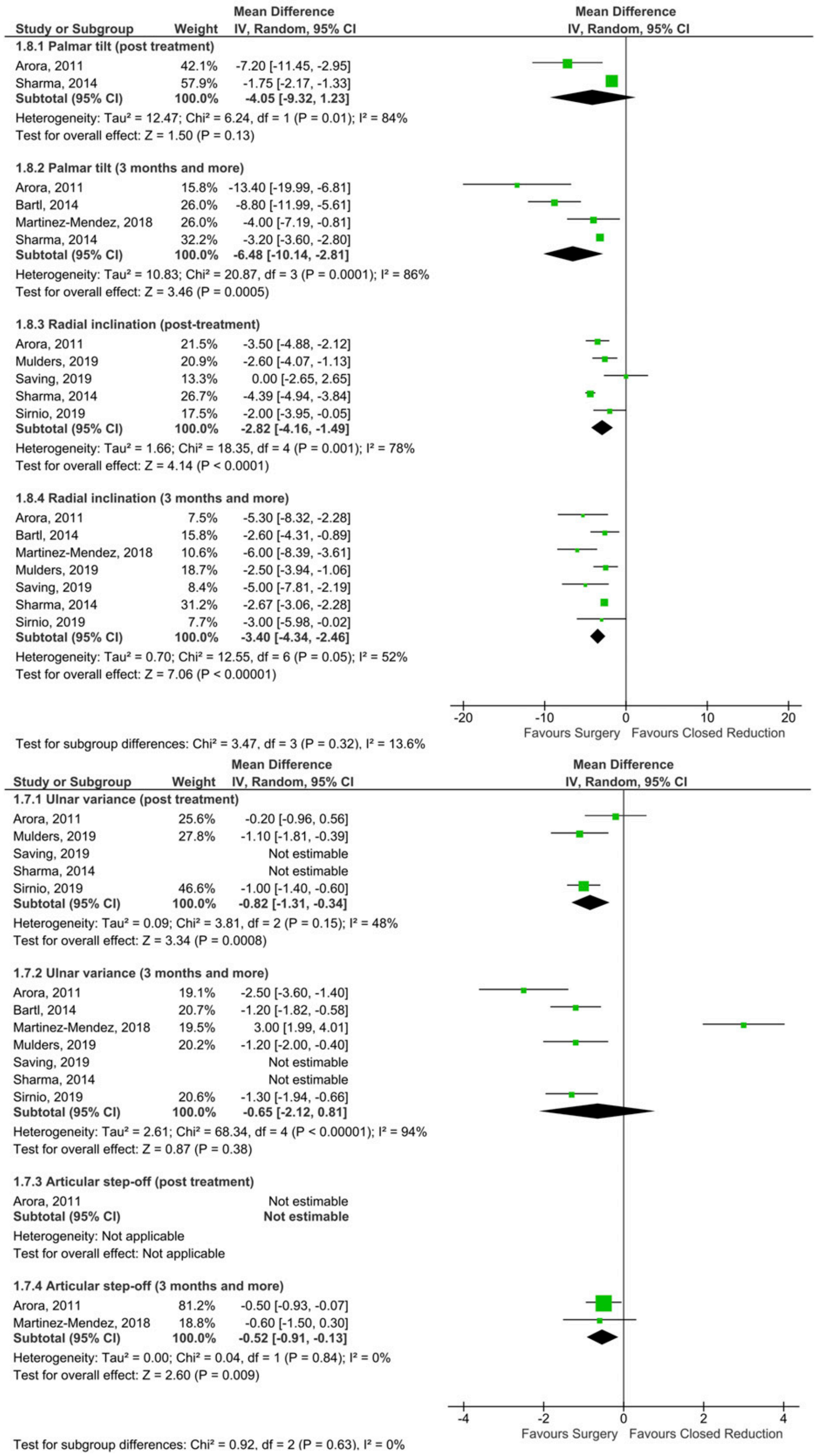

Fig. 4

Forest plots for radiographic outcomes including palmar tilt, radial inclination, ulnar variance, and articular stepoff. The following time frames for radiographic outcomes were used in this meta-analysis: Arora, post-treatment and 12 months; Bartl, 3 months; Martinez-Martinez, 24 months; Mulders, 1 week and 12 months; Saving, post-treatment and 12 months; Sharma; post-treatment and 12 months; Sirniö, post-treatment and 24 months. Ulnar variance outcomes for Sirniö have been converted from negative to positive values. IV = inverse variance, and df = degrees of freedom.

Outcomes	Anticipated absolute effects* (95% CI)		№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Outcome with non-surgery (closed reduction)	**Outcome with surgery (volar locking plate fixation)**			
Patient-reported function (PRWE) - PRWE 12 months	The mean patient-reported function (PRWE) - PRWE 12 months was **19.6**	MD **6.9 points** (95% CI: 0.6 to 14.3)	192 (2 RCTs)	⊕⊕◯◯ LOW a,b,c,d	The MCID for PRWE has been reported as 14 points [27] or 11.5 points for wrist fractures [29]. Surgery (volar locking plate fixation) may result in little to no clinically important difference in patient-reported function (PRWE) at 12 months post treatment but the evidence is uncertain.
Patient-reported function (DASH) - DASH 12 months	The mean patient-reported function (DASH) - DASH 12 months was **14.5**	MD **4.1 points** (95% CI: 1.2 to 7.0)	421 (4 RCTs)	⊕⊕⊕◯ MODERATE a,c,e,f	The MCID for DASH has been reported as 10 points [1]. Surgery (volar locking plate fixation) likely results in little to no clinically important difference in patient-reported function (DASH) at 12 months post treatment.
Patient-reported function (DASH) - DASH 24 months	The mean patient-reported function (DASH) - DASH 24 months was **16.9**	MD **8.9 points** (95% CI: 5.8 to 12.1)	241 (3 RCTs)	⊕⊕◯◯ LOW a,d,f,g	The MCID for DASH has been reported as 10 points [1]. Surgery (volar locking plate fixation) may result in little to no clinically important difference in patient-reported function (DASH) at 24 months post treatment but the evidence is uncertain.
Quality of life (EQ-5D-5L) - EQ-UI 12 months	The mean quality of life (EQ-5D-5L) - EQ-UI 12 months was **0.85**	MD **0.01 points** (95% CI: -0.04 to 0.06)	268 (2 RCTs)	⊕⊕◯◯ LOW a,c,d,e	Surgery (volar locking plate fixation) may result in little to no clinically important difference in quality of life (EQ-UI) long-term but the evidence is uncertain.

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. All included studies were liable to performance bias

b. The Arora Study had undefined randomization and was liable to attrition bias given the low overall follow-up (73/90 = 81%)

c. The Saving Study was liable to attrition bias given the low overall follow-up (119/140 = 85%) and differential loss to follow-up (56/68 = 82% for surgery group and 63/72 = 88% for non-surgery

d. Total sample size was less than 400 (optimal information size for continuous outcomes)

e. The Bartl Study was liable to attrition bias given the low overall follow-up (149/185 = 81%) and the differential follow-up (68/94 = 72% for surgery and 81/91 = 89% for non-surgery). Also, 42% crossed over

f. The Sirnio study was liable to attrition bias given low overall follow-up at 3 months and at 24 months (68/80 = 85%) and differential follow-up (33/38 = 87% for surgery and 35/42 = 83% for non-surgery)

g. The Sharma Study is liable to selection bias given that there was no true randomisation and allocation concealment

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Fig. 5
GRADE summary of findings for patient-reported outcomes for closed reduction and volar locking plate fixation.

Outcomes	Anticipated absolute effects* (95% CI)		№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with non-surgery (closed reduction)	Risk with surgery (volar locking plate fixation)			
Radiographic outcomes (adjusted) - Palmar tilt (3 months and 12 months)	The mean radiographic outcomes (adjusted) - Palmar tilt (3 months and more) were **10.9 degrees**	MD **6.5 lower** (10.1 lower to 2.8 lower)	389 (4 RCTs)	⊕◯◯◯ VERY LOW a,b,c,d,e	Surgery (volar locking plate fixation) may result in better radiographic outcomes - Palmar tilt but the evidence is very uncertain.
Radiographic outcomes (adjusted) - Radial inclination (3 months and 12 months)	The mean radiographic outcomes (adjusted) - Radial inclination (3 months and more) were **6.9 degrees**	MD **3.4 lower** (4.3 lower to 2.5 lower)	654 (7 RCTs)	⊕⊕◯◯ LOW a,b,c,e,f,g,h,i	Surgery (volar locking plate fixation) may result in better radiographic outcomes - Radial inclination but the evidence is uncertain
Radiographic outcomes (mms) - Ulnar variance (3 months and 12 months)	The mean radiographic outcomes (mms) - Ulnar variance (3 months and more) were **1.5 millimetres**	MD **0.7 lower** (2.1 lower to 0.8 higher)	543 (6 RCTs)	⊕⊕◯◯ LOW a,b,c,f,h,i,j	Surgery (volar locking plate fixation) may result in better radiographic outcomes - Ulnar variance but the evidence is uncertain

Explanations

a. All included studies were at risk of performance bias

b. The Arora Study had undefined randomization and was at risk of attrition bias given the low overall follow-up (73/90 = 81%)

c. The Bartl Study was at risk of attrition bias given the low overall follow-up (149/185 = 81%) and the differential follow-up (68/94 = 72% for surgery and 81/91 = 89% for non-surgery). Also, 42% crossed over

d. Total sample size was less than 400 (optimal information size for continuous outcomes)

e. In the Sharma study, palmar tilt and radial inclination results produced asymmetry on funnel plots. The treatment effects were large and out of proportion compared to other studies.

f. The Mulders study was at risk of selection bias on the basis of uncertain allocation concealment

g. The Saving Study was at risk of attrition bias given the low overall follow-up (119/140 = 85%) and differential loss to follow-up (56/68 = 82% for surgery group and 63/72 = 88% for non-surgery

h. The Simio study was at risk of attrition bias given low overall follow-up at 3 months and at 24 months (68/80 = 85%) and differential follow-up (33/38 = 87% for surgery and 35/42 = 83% for non-surgery)

i. The Sharma Study is liable to selection bias given that there was no true randomisation and allocation concealment

j. There is high heterogeneity for this outcome I2=92%, with one study (Martinez-Mendez) showing an effect that is contralateral to the others.

Fig. 6

GRADE summary of findings for radiographic outcomes for closed reduction and volar locking plate fixation.

Cochrane Library[46], and the other is still ongoing[47].

Strengths and Limitations

This meta-analysis is the first, to our knowledge, to compare exclusively the 2 most common forms of treatment for distal radial fractures. This question is of current clinical interest and importance; of the 8 studies included in our review, all are RCTs and 4 were published in 2018 or 2019. Given this emerging evidence, an up-to-date synthesis of the evidence can provide solid evidence on which to base shared decision-making and clinical practice guidelines.

The unknown clinical importance of range of motion and radiographic outcomes was a limitation of this study. For range-of-motion outcomes, we could find no relevant MCIDs to provide a benchmark measure. For radiographic outcomes, there is wide variability in the choice and definition of measures used in the literature regarding distal radial fractures[32]. Clinical importance would perhaps best be informed by fracture displacement thresholds, but a recent systematic review from the British Orthopaedic Association could not define thresholds for acceptable displacement[20]. The difficulty in defining thresholds is unsurprising given that the literature comparing long-term functional outcomes with radiographic outcomes reported little, if any, agreement[48-50]. Also, there was potential for bias in the radiographic findings; given that there was a variable rate of crossover in the included studies (0% to 41%), it is possible that those participants who converted to surgery improved the overall radiographic profile of the CR group and that the between-group difference was therefore underestimated. One included study posed a risk of selection bias, given that treatment allocation was pseudorandomized (alternate allocation). The results were included in this review, but these methodological limitations may explain any difference between that study and the other included studies.

Another limitation was the wide variety of clinical and patient-reported outcomes reported at disparate time frames in the included studies. To mitigate this, we focused on patient-reported outcomes and on 12 and 24-month follow-up time points, allowing us to address the dearth of evidence available for longer-term outcomes so important in guideline development. In addition, the included studies used a variety of participant age inclusion criteria, and we were concerned that the pooling of results might have obscured important age-specific outcomes. However, our sensitivity analysis found that restricting analyses to older participants made little difference in the magnitude and direction of effects for key outcomes (see Appendix 4.1).

Conclusions

In this systematic review and meta-analysis of 8 RCTs comparing VLP fixation and CR for the treatment of distal radial fractures, no clinically important differences were found between treatments in terms of patient-reported pain, function, and quality-of-life outcomes at 12 months, despite VLP fixation leading to better fracture alignment.

Appendix

Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJSREV/A660).

Andrew Lawson, BAppSc(Phty), MPH[1],
Michael Na, MBBS[1],
Justine M. Naylor, BAppSc(Phty), PhD[1],
Adriane M. Lewin, MSc(Epidemiology)[1],
Ian A. Harris, MBBS, MMed(ClinEpi), PhD[1]

[1]Whitlam Orthopaedic Research Centre, Ingham Institute for Applied Medical Research, South Western Sydney Clinical School, University of New South Wales (UNSW) Australia, Sydney, New South Wales, Australia

Email address for A. Lawson: aalawson@tpg.com.au
Email address for I.A. Harris: iaharris1@gmail.com

ORCID iD for A. Lawson: 0000-0002-1367-6443
ORCID iD for M. Na: 0000-0003-3241-4382
ORCID iD for J.M. Naylor: 0000-0002-9147-1312
ORCID iD for A.M. Lewin: 0000-0001-6258-3692
ORCID iD for I.A. Harris: 0000-0003-0887-7627

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