Comparison of effects of seven treatment methods for distal radius fracture on minimizing complex regional pain syndrome

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Abstract

Introduction: Using network meta-analysis, we evaluated the adverse effects of the seven most common treatment methods, i.e., bridging external fixation, non-bridging external fixation, K-wire fixation, plaster fixation, dorsal plating, volar plating, and dorsal and volar plating, by their associated risk of developing complex regional pain syndrome (CRPS) in distal radius fracture (DRF) patients.

Material and methods: Following an exhaustive search of scientific literature databases for high quality studies, randomized controlled trials (RCTs) related to our study topic were screened and selected based on stringent predefined inclusion and exclusion criteria. Data extracted from the selected studies were used for statistical analyses using Stata 12.0 software.

Results: A total of 17 RCTs, including 1658 DRF patients, were enrolled in this network meta-analysis. Among the 1658 DRF patients, 452 received bridging external fixation, 525 received non-bridging external fixation, 154 received K-wire fixation, 84 received plaster fixation, 132 received dorsal plating, 123 received volar plating, and 188 received dorsal and volar plating. When compared to bridging external fixation patients, there was no marked difference in the CRPS risk in DRF patients receiving different treatments (all $p > 0.05$). However, the surface under the cumulative ranking curves (SUCRA) for plaster fixation (77.0%) and non-bridging external fixation (71.3%) were significantly higher compared with the other five methods.

Conclusions: Our findings suggest that compared with bridging external fixation, K-wire fixation, dorsal plating, volar plating, dorsal and volar plating, plaster fixation and non-bridging external fixation might be the better treatment methods to reduce the risk of CRPS in DRF patients.

Key words: distal radius fracture, plaster fixation, dorsal and volar plating, randomized controlled trials, complex regional pain syndrome, network meta-analysis, treatment relative ranking of predictive probabilities.

Introduction

Distal radius fractures (DRFs) are the most frequent fractures in upper extremities and are a serious public health concern, especially in the older age groups [1]. The underlying injury is frequently associated with falling from a standing height; therefore, slippery conditions are a major risk factor, and it is also seen in high-impact or trauma-related injuries [2]. DRFs are endemic in the Medicare population, and over 85,000 beneficiaries sustain DRFs each year, which is a significant burden in

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healthcare costs and in patient care [3]. Etiologically, the reasons are likely multifactorial, and the incidence of DRFs is steadily increasing in the US and many other countries around the world, mostly attributed to aging populations [4]. Known risk factors for DRFs include previous low-energy fracture and a family history of fracture [5]. The peak age for trauma differs between men and women, with men sustaining high-energy injuries around a peak age of 30 years, while in women postmenopausal changes increase the incidence of injuries, irrespective of the height of the fall [6]. Complex regional pain syndrome (CRPS) is a devastating condition, commonly encountered after DRFs. Its incidence is significantly high, and varies between 10.5% and 37% [7]. Complex regional pain syndrome is characterized by pain combined with autonomic, sensory, trophic, as well as motor abnormalities [8]. Further, abnormal sensory, motor, sudomotor, vasomotor, and trophic changes are mandatory diagnostic criteria [9]. The goal of DRF treatment is to restore the affected upper extremity within the acceptable mobility and durability requirements [10]. Most DRF treatments are associated with some known risks including the occurrence of CRPS, especially invasive surgical treatments [11].

Bridging external fixation of the wrist for DRF is performed to maintain reduction, but it may result in the loss of palmar tilt [12]. Non-bridging external fixation is directly applied to fix the distal and proximal fragments together, based on closed fracture reduction, followed by employment of an external fixator [13]. It may better accelerate fracture reduction and secure fixation, facilitate functional recovery and ameliorate wrist motion [14]. K-wires are relatively cheap and have many-sided applications. Insertion of K-wires is a common surgical technique for bone stabilization in the hand and wrist [15]. It is a minimally invasive procedure and is associated with good patient outcomes [6]. Plaster fixation is typically used in stable fractures, and braking after fracture operation, and is cheap, easy to use, non-invasive, and easy to achieve the treatment principles of three-point suspension [16]. Dorsal fixation allows direct exposure and reconstruction of the joint by a capsular incision, but requires dissection of the extensor retinaculum and subsequent plate positioning beneath the tendon, which often leads to tendonitis or tendon rupture [17]. Volar plating is designed to allow direct reduction, solid fixation and early mobilization of wrist fractures. The construction of a fixed angle provides a strong fixation in osteoporotic bone and comminuted fractures [18]. It exploits the anatomy of the volar distal radius and aims to avoid the soft tissue complications observed with dorsal plates [18]. A number of studies have shown that bridging external fixation, non-bridging external fixation, K-wire fixation, plaster fixation, dorsal plating, volar plating and dorsal and volar plating have high efficacy for DRF treatment [12, 17, 19]. However, there have been several attempts to rank the seven treatment strategies, and disagreements exist on their efficacy in treatment of DRF [11, 15, 20].

Compared to traditional meta-analysis, network meta-analysis that uses a common comparator in the abscence of two direct comparisons and gives acess to relevant direct and indirect comparisons to rank several interventions simultaneously [21, 22]. In view of the advantages of network analysis, we conducted this network meta-analysis aiming to assess and rank the therapies of bridging external fixation, non-bridging external fixation, K-wire fixation, plaster fixation, dorsal plating, volar plating and dorsal and volar plating in reducing CRPS risk in DRF patients.

Material and methods

Search methods for identification of articles

We searched PubMed, EBSCO, Ovid, Springerlink, Wiley, Web of Science and Cochrane Library for relevant studies published prior to October, 2014. Studies published in Chinese or English languages were retrieved using a combination of keywords and subject terms. We also manually searched the bibliographies of relevant literature to identify additional relevant studies. The following subject terms and key words were used to maximize the search specificity and sensitivity: distal radius fracture, complex regional pain syndrome, external fixation, internal fixation, bridging external fixation, non-bridging external fixation, K-wire fixation, plaster fixation, dorsal plating, volar plating and dorsal and volar plating.

Study selection

Studies published in Chinese and English languages were selected in this network meta-analysis if they met criteria as follows: (1) study types were randomized controlled trials (RCTs); (2) interventions were bridging external fixation, non-bridging external fixation, K-wire fixation, plaster fixation, dorsal plating, volar plating or dorsal and volar plating; (3) research subjects were confirmed clinically and by imaging as DRF patients; (4) end outcome was incidence of CRPS. The exclusion criteria were: (1) non-RCT; (2) repeatedly published studies; (3) lack of data integrity; (4) combined use of interventions.

Data extraction and methodological quality of included studies

Two investigators extracted the data independently, based on a predefined data collection table. The main extracted information included first author, publication year, country, ethnicity, language, disease, age, gender, and number of cases. Disagreements on data extractions were resolved by discussion.

Methodological quality of included RCTs was evaluated by two or more investigators using Cochrane Collaboration's tool to assess risk of bias [23]. The risk of bias covers six domains, including allocation concealment, random sequence generation, blinding of participants or blinding outcome evaluation, selective reporting and other bias, and incomplete outcome data. The detailed assessment criteria were: (1) whether the allocation sequence is properly generated; (2) whether the method applied to conceal the allocation sequence is appropriate; (3) whether the intended blinding is effective; (4) whether the incomplete outcome data are appropriately dealt with; (5) how selective outcome reporting is examined and what is found; (6) whether any other important concerns about bias are covered in the other domains in the tool.

Statistical analysis

We conducted all statistical analyses with Stata software, version 12.0 (Stata Corporation, College Station, Texas, USA). Odds ratio (OR) with 95% confidence intervals (95% CI) was evaluated using a fixed-effects model or a random-effects model to assess the influence of intervention group and control group on CRPS of DRF patients. The Z test was applied to measure the pooled effect size [24]. Heterogeneity across enrolled studies was assessed using Cochran Q and I^2 statistics [25, 26]. A random-effects model was used when there was great heterogeneity ($I^2 > 50\%$); otherwise, a fixed-effects model was performed. Network meta-analysis analyzes data from a network of studies involving three or more interventions. The integration between direct evidence obtained from trials directly comparing interventions and indirect evidence that provided information about two treatments derived by a common comparator enhances the accuracy in evaluation and ranks all the treatments for the studied outcome [27]. In each closed loop, we use the inconsistency factor (IF) to evaluate heterogeneity across studies. If the 95% CI of IF values are truncated at zero, it indicates unimportance of the direction of the IF [28]. Funnel plots, which reflect the presence of small-study effects, further provide validation for the reliability of the final results [29]. The assumption of consistency models allows the presence of heterogeneity of the intervention effects among studies while no significant differences in study design exist. After the generation of the heterogeneity matrix, the frequentist method was used for the fitted model to calculate the ranking probabilities [30]. We used two ways to rank the treatments. First, posterior probabilities of outcomes were used to calculate probabilities of treatment ranking. Second, the surface under the cumulative ranking probabilities (SUCRA) was used to identify which treatment was the best one.

Results

Trial characteristics

The electronic database search initially retrieved 1218 studies, of which 17 studies [14, 31–46] met the inclusion criteria for the current network meta-analysis. The studies were eliminated for being duplicates ($n = 225$), letters, reviews, or meta-analyses ($n = 29$), not human studies ($n = 13$), not related to DRF ($n = 273$), not RCT ($n = 219$), studies not relevant to CRPS ($n = 306$), not relevant to network ($n = 129$), without data ($n = 4$) and studies that had insufficient information or weakly correlated data ($n = 3$). The remaining 17 cohort studies, published between 1996 and 2012, were selected for meta-analysis and contained a combined total of 1658 DRF patients (452 bridging external fixation, 525 non-bridging external fixation, 154 K-wire fixation, 84 plaster fixation, 132 dorsal plating, 123 volar plating, 188 dorsal and volar plating). The flow diagram describes the results of the electronic search. Of the 17 trials, 2 trials were performed in Asians and 15 trials were performed in Caucasians. Additionally, all included studies were two-arm trials and had a total of 17 comparisons. The baseline characteristics and Cochrane assessment of risk of bias are shown in Table I and Figure 1, respectively.

Evidence network

Figure 2 shows the network of clinical trials based on the comparisons of the seven specific treatment methods, as well as point estimates for the results of traditional meta-analyses. Connecting lines represent direct comparison between the two connected interventions, and pairs of interventions without connection can be compared indirectly by network meta-analysis. The width of lines corresponds to the number of trials, and the size of the node corresponds to the overall sample size of intervention. The color of lines represents the risk of bias of enrolled trials. This study contained seven treatment methods including bridging external fixation, non-bridging external

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Table I. Baseline characteristics of included studies

First author	Year	Country	Ethnicity	Intervention T1	Intervention T2	Total	Sample size T1	Sample size T2	Gender (M/F) T1	Gender (M/F) T2	Age [years] T1	Age [years] T2
McQueen [40]	1996	UK	Caucasians	Plaster	EF (B)	60	30	30	2/28	4/26	64 ±14.5	63 ±11.6
McQueen [39]	1998	UK	Caucasians	EF (NB)	EF (B)	60	30	30	3/27	2/28	62 ±14	61 ±13
Krishnan [38]	2003	Australia	Caucasians	EF (NB)	EF (B)	60	30	30	12/18	7/23	58 (18–82)	55 (19–83)
Grewal [34]	2005	Canada	Caucasians	K-wire	D	62	33	29	21/12	12/17	45 ±2.7	46 ±2.7
Kreder [37]	2005	USA	Caucasians	EF (NB)	V + D	179	88	91	50/38	59/32	40 (20–78)	39 (20–81)
Westphal [41]	2005	Germany	Caucasians	K-wire	V + D	131	77	54	31/46	26/28	60.6 ±15.3	59.5 ±15.8
Wright [44]	2005	USA	Caucasians	V	EF (B)	32	21	11	11/10	3/8	50.1 (19–74)	50 (21–64)
Atroshi [14]	2006	Sweden	Caucasians	EF (NB)	EF (B)	38	19	19	3/16	4/15	70 (55–86)	71 (57–84)
Hayes [35]	2008	Canada	Caucasians	EF (NB)	EF (B)	588	358	230	47/311	71/159	64	58
Abramo [31]	2009	Sweden	Caucasians	D	EF (B)	50	26	24	14/36		48 (20–65)	
Xu [45]	2009	Singapore	Asians	K-wire	V + D	30	14	16	9/5	9/7	45.3 (35–55)	41.8 (21–56)
Aktekin [32]	2010	Turkey	Caucasians	Plaster	EF (B)	46	24	22	5/19	9/13	71.2 ±5.2	69.8 ±4.5
Wong [43]	2010	China	Asians	Plaster	K-wire	60	30	30	5/25	6/24	71 (65–76)	70 (66–76)
Grewal [33]	2011	Canada	Caucasians	V + D	EF (B)	53	27	26	6/20	6/18	58 ±9.9	53.8 ±11.7
Wilcke [42]	2011	Sweden	Caucasians	V	EF (B)	63	33	30	30/25	33/23	55 (20–69)	56 (21–69)
Yu [46]	2011	USA	Caucasians	D	V	104	57	47	40/64		51 (19–85)	56 (19–84)
Jakubietz [36]	2012	Germany	Caucasians	D	V	42	20	22	3/17	3/19	67.6 (52–85)	67.7 (52–92)

T – treatment, M – male, F – female, Plaster – plaster fixation, EF (B) – bridging external fixation, EF (NB) – non-bridging external fixation, D – dorsal plating, V – volar plating, D + V – dorsal and volar plating, K-wire – K-wire fixation.
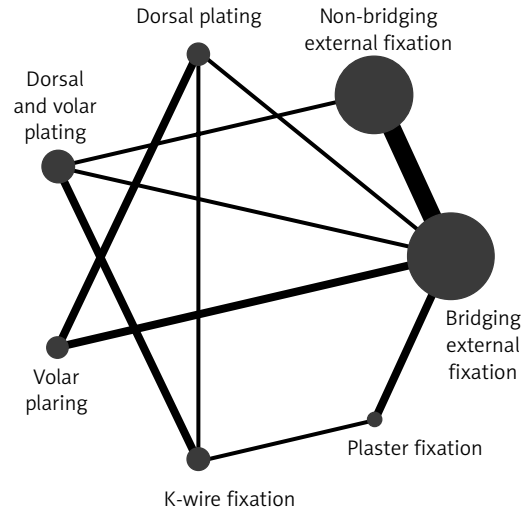
Figure 1. Risk of bias in selected randomized controlled trials (RCTs) using Cochrane Collaboration's tool
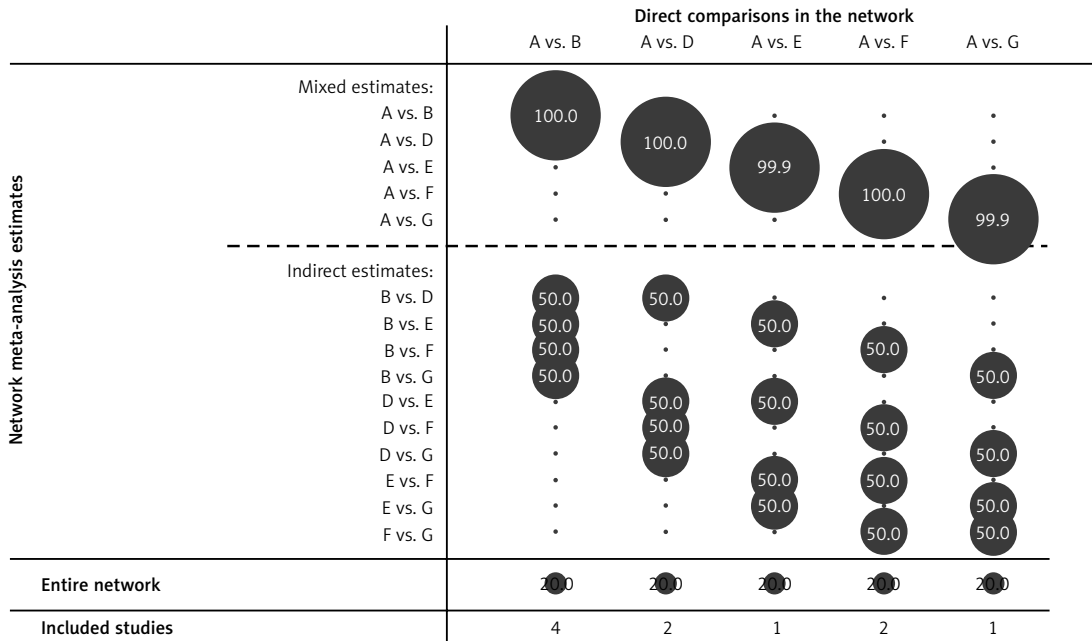

Figure 2. The evidence network for trials enrolled in this network meta-analysis

dorsal and volar plating was 50%, 50%, 50%, 50% and 50%, respectively, 25% for the overall network meta-analysis; (2) two studies directly compared bridging external fixation and plaster fixation, whose percentage contribution to non-bridging external fixation vs. plaster fixation, plaster fixation vs. dorsal plating, plaster fixation vs. volar plating, and plaster fixation, dorsal and volar plating was 50%, 50%, 50%, 50% and 50%, respectively, 25% for the overall network meta-analysis; (3) one trial directly investigated bridging external fixation vs. dorsal plating, whose percentage contribution to non-bridging external fixation vs. dorsal plating, plaster fixation vs. dorsal plating, dorsal plating vs. volar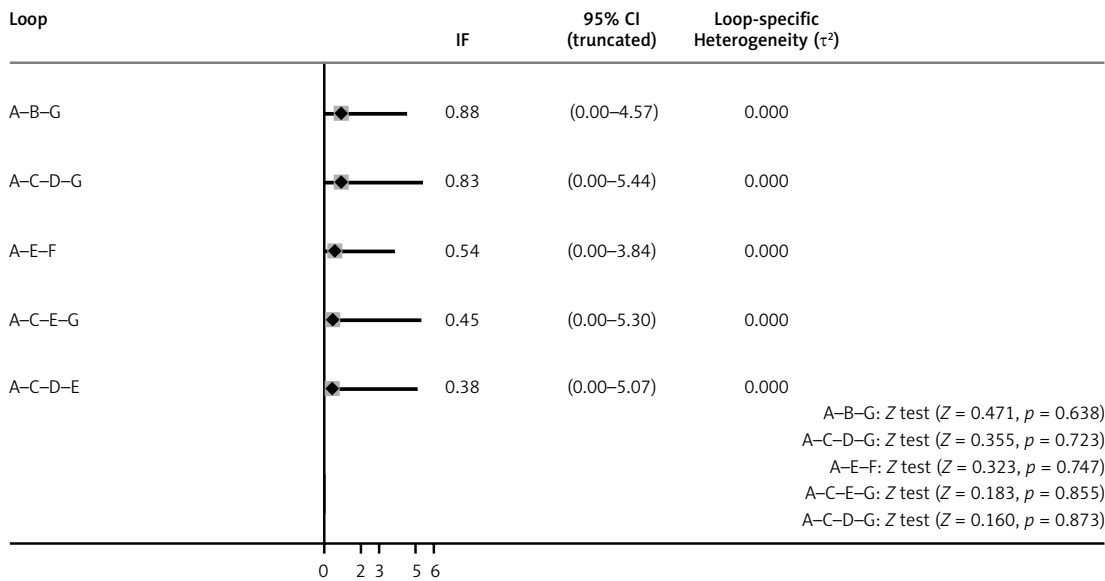 plating, and dorsal plating vs. dorsal and volar plating was 50%, 50%, 50%, 50% and 50%, respectively, 20% for the overall network meta-analysis; (4) two studies directly explored bridging external fixation vs. volar plating, whose percentage contribution to non-bridging external fixation vs. volar plating, plaster fixation vs. volar plating, dorsal plating vs. volar plating, and volar plating vs. dorsal and volar plating were 50%, 50%, 50%, 50% and 50%, respectively, 20% for the overall network meta-analysis; (5) one trial studied bridging external fixation vs. dorsal and volar plating, whose percentage contribution to non-bridging external fixation vs. dorsal and volar plating, plaster fixation vs. dorsal and volar plating, dorsal plating vs. dorsal and volar plating, and volar plating vs. dorsal and volar plating were 50%, 50%, 50%, 50% and 50%, respectively, 20% for the overall network meta-analysis.

Evaluating and presenting assumptions of network meta-analysis

An inconsistency plot was applied to test the heterogeneity across studies in the closed loop of this network meta-analysis (Figure 4). This net-

fixation, K-wire fixation, plaster fixation, dorsal plating, volar plating and dorsal and volar plating.

Contribution plot

Each direct comparison contributes differently to the estimation of this network's overall effects, and the details are shown in Figure 3: (1) 4 trials directly compared bridging external fixation and non-bridging external fixation, whose percentage contribution to non-bridging external fixation vs. plaster fixation, non-bridging external fixation vs. dorsal plating, non-bridging external fixation vs. volar plating, and non-bridging external fixation vs.

Figure 3. Contribution plot of studies included in this network meta-analysis

A – bridging external fixation, B – non–bridging external fixation, D – plaster fixation, E – dorsal plating, F – volar plating, G – dorsal and volar plating.

A–B–G: *Z* test (*Z* = 0.471, *p* = 0.638)
A–C–D–G: *Z* test (*Z* = 0.355, *p* = 0.723)
A–E–F: *Z* test (*Z* = 0.323, *p* = 0.747)
A–C–E–G: *Z* test (*Z* = 0.183, *p* = 0.855)
A–C–D–G: *Z* test (*Z* = 0.160, *p* = 0.873)

Figure 4. Inconsistency test for direct and indirect comparisons

A – bridging external fixation, B – non-bridging external fixation, C – K-wire fixation, D – plaster fixation, E – dorsal plating, F – volar plating, G – dorsal and volar plating.

work meta-analysis consists of two closed-loop triangles and 3 closed-loop quadrilaterals, including the bridging external fixation-non-bridging external fixation-dorsal and volar plating loop, the bridging external fixation-K-wire fixation-plaster fixation-dorsal and volar plating loop, the bridging external fixation-dorsal plating-volar plating loop, the bridging external fixation-K-wire fixation-dorsal plating-dorsal and volar plating loop, and the bridging external fixation-K-wire fixation-plaster fixation-dorsal plating loop. The 95% CI of IF val-

ues are truncated at zero, suggesting that there is no significant inconsistency. The *p*-values of these closed loops (all *p* > 0.05) further confirmed that the direct comparisons together with indirect comparisons of the five closed loops have consistency.

Comparisons of efficacy of the seven treatments for DRF

Network meta-analysis results demonstrated that there was no significant difference in the risk of CRPS between DRF patients receiving

Table II. Comparisons of the complex regional pain syndrome in distal radius fracture patients treated with 7 different treatments
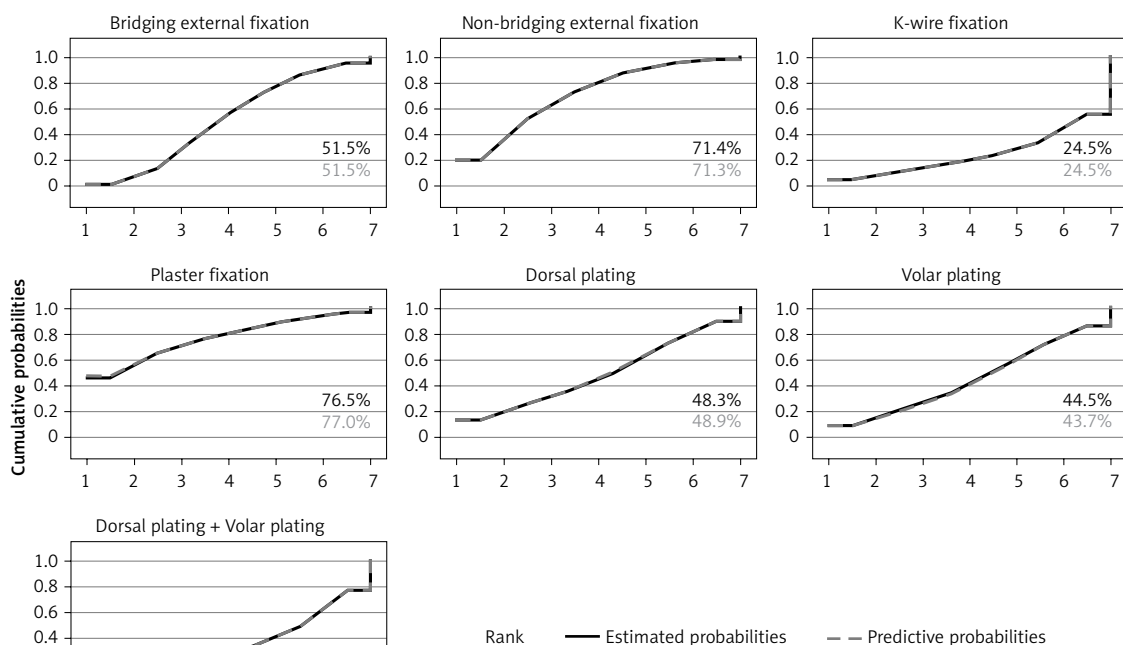
Comparisons	CRPS (correlation not ignored)				CRPS (correlation ignored)			
	OR	95% CI		Z	OR	95% CI		Z
		LL	UL			LL	UL	
EF (NB) vs. EF (B)	0.762	0.420	1.383	−0.89	0.763	0.419	1.387	−0.89
K-wire vs. EF (B)	2.097	0.299	14.689	0.75	2.133	0.159	28.440	0.57
Plaster vs. EF (B)	0.609	0.178	2.082	−0.79	0.609	0.178	2.082	−0.79
D vs. EF (B)	1.143	0.258	5.060	0.18	0.439	0.037	5.175	−0.65
V vs. EF (B)	1.209	0.327	4.469	0.28	1.726	0.378	7.882	0.70
D + V vs. EF (B)	1.631	0.327	8.138	0.60	1.644	0.269	10.063	0.54

CRPS – complex regional pain syndrome, OR – odds ratio, 95% CI – 95% confidential intervals, EF (NB) – non-bridging external fixation, EF (B) – bridging external fixation, K-wire – K-wire fixation, Plaster – Plaster fixation, D – dorsal plating, V – volar plating, D + V – dorsal and volar plating.

bridging external fixation and those receiving non-bridging external fixation, K-wire fixation, plaster fixation, dorsal plating and volar plating (non-bridging external fixation: OR = 0.762, 95% CI = 0.420–1.383, *p* = 0.372; K-wire fixation: OR = 2.097, 95% CI = 0.299–14.689, *p* = 0.456; plaster fixation: OR = 0.609, 95% CI = 0.178–2.082, *p* = 0.429; dorsal plating: OR = 1.143, 95% CI = 0.258–5.060, *p* = 0.860; volar plating: OR = 1.209, 95% CI = 0.327–4.469, *p* = 0.776; dorsal and volar plating: OR = 1.631, 95% CI = 0.327–8.138, *p* = 0.551). After ignoring covariance, further analysis suggests no significant differences among results (Table II).

Ranking of interventions

The treatment relative ranking of estimated probabilities of the seven treatments for DRF patients were: 51.5% (bridging external fixation), 71.4% (non-bridging external fixation), 24.5% (K-wire fixation), 76.5% (plaster fixation), 48.3% (dorsal plating), 44.5% (volar plating) and 33.2% (dorsal and volar plating). The SUCRA values of the seven treatments' relative ranking of predictive probabilities were 51.5% for bridging external fixation, 71.3% for non-bridging external fixation, 24.5% for K-wire fixation, 77.0% for plaster fixation, 48.9% for dorsal plating, 43.7% for volar

Figure 5. Surface under the cumulative ranking curves of treatment relative ranking of predictive probabilities for comparisons of the complex regional pain syndrome in distal radius fracture treated with 7 treatments

plating and 33.2% for dorsal and volar plating, suggesting that plaster fixation and non-bridging external fixation might be the optimum treatments for DRF for the lowest occurrence of CRPS, compared with bridging external fixation, K-wire fixation, dorsal plating, volar plating and dorsal and volar plating (Figure 5).
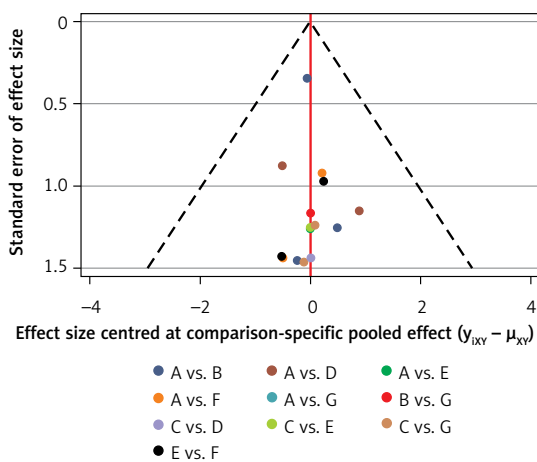
Assessment of publication bias

Figure 6 presents the funnel plot for the seven interventions network which provides an indication for the presence of a small-study effect. All the included studies are symmetrically distributed around the vertical line ($x = 0$), suggesting no evidence of a small-study effect in the network.

Discussion

Distal radius fracture are the most common pediatric orthopedic injuries, and their incidence has increased over the last three decades. A majority of distal radius fractures can be treated successfully with a closed reduction and plaster immobilization alone. In this network meta-analysis, we aimed to rank the seven available treatment modalities, including bridging external fixation, non-bridging external fixation, K-wire fixation, plaster fixation, dorsal plating, volar plating, and dorsal and volar plating, for their associated complication in treatment of DRFs. In this setting, we found no marked differences in CRPS risk between patients treated with bridging external fixation, non-bridging external fixation, K-wire fixation, plaster fixation, dorsal plating, volar plating, and dorsal and volar plating. The SUCRA values of plaster fixation and non-bridging external fixation were, however, significantly higher compared with the other five modalities, suggesting that plaster fixation and

non-bridging external fixation might be better choices in treatment of DRF, to reduce the incidence of CRPS. SUCRA is a simple transformation of mean rank and is applied to supply a hierarchy of treatments. Greater SUCRA values indicate higher rank of the treatment [47]. As we know, plaster fixation is the first-line treatment for DRFs because it facilitates retention of the reduced position. For instance, it can provide a better fixation effect compared to an orthosis. A plaster cast could be split and spread to relieve pressure by 65%, and thereby it has been a well-established modality, allowing for expansion of the soft tissues after trauma or injury [48]. Splitting the cast ensured the structural stability to be maintained while lowering the CRPS risk from swelling via reducing pressure [48]. This method is cheap, easy to use, non-invasive, and easy to achieve the treatment principle of three-point suspension, and its fixed effect is excellent, making it a practical approach of external fixation [16]. The main disadvantage of plaster fixation is that it can cause various complications, including compartment syndrome, pressure ulcers, infection, dermatitis, joint contracture, and nerve damage [49]. A poorly or incorrectly applied plaster can result in failure of immobilization resulting in ongoing pain and deformity, pressure necrosis of the skin, compartment syndrome, stiffness, thermal injury and nerve palsy. Nevertheless, a well-applied plaster can provide safe and comfortable immobilization of a fracture prior to operative management or as part of definitive management of an injury. Non-bridging external fixation for DRFs was introduced as a versatile tool to combine closed reduction and faster functional recovery after treatment [19]. The non-bridging external fixator is indicated in extra-articular, dorsally displaced fractures, and has the advantage of reducing the fracture, allowing direct movement of the distal fragment through using the pins as a joystick, and enabling early movement of the wrist [13]. In line with our findings in this meta-analysis, a study by Windolf *et al.* suggested that non-bridging external fixation provided sufficient stabilization in restoring and retaining anatomy after most DRFs [19]. Potestio *et al.* also investigated the effectiveness in 56 DRF patients who received non-bridging external fixation, and all patients showed excellent or good clinical outcomes [50].

Additionally, various risk factors including age and gender, as well as time/onset of pain (pre/post-operative or fixation), have been reported to be associated with CRPS. Age has been considered as a consistent potential risk factor for the onset of CRPS, and higher CRPS risk was correlated with older age [51, 52]. Female sex (particularly postmenopausal) poses a higher risk for the onset of CRPS [53], while the study focused on men in the armed forces by Duman *et al.* suggests that men

Figure 6. Funnel plots assessment of publication bias of all included studies

A – bridging external fixation, B – non-bridging external fixation, C – K-wire fixation, D – plaster fixation, E – dorsal plating, F – volar plating, G – dorsal and volar plating.

are also vulnerable [54]. Moreover, it is well established that the time of pain (pre/post-operative or fixation) could also influence the risk of CRPS to some extent. In this study, no significant difference existed in age, gender, or time/onset of pain among patients receiving different treatment methods, which further validated the reliability of the final results to some extent.

Of note, there were several strengths of our study. First, the methods of analysis were systematic and exhaustive. Funnel plots were used to identify potential publication bias because of small-study effects, which have the possibility to result in higher treatment effects compared with large studies. One of the advantages of this network meta-analysis is its ability to use information about specific treatment groups from other trials, and thereby to increase the overall sample sizes. Second, included trials were performed in different regions, which strengthens the external validity. Third, a comprehensive search strategy was used, which assured that all available trial data were selected. Fourth, statistical uncertainty in this network meta-analysis was relatively low, thereby strengthening the confidence in the results.

Nevertheless, these methods also have limitations. First, although all trials were RCTs, most trials were unclear in relevant randomization sequence generations; consequently, selection bias or confounding factors might influence our final results. There was heterogeneity in pooled results, and the source of the difference was often not apparent. Second, grouping treatments that have important differences in rationale and procedures might obscure differences between treatments and cause us to underestimate the relative efficacy of treatment methods. Third, only a limited number of trials ($n = 17$) were included in the current network meta-analysis. Consequently, even though the inter-trial heterogeneity was low and could be estimated precisely enough for the primary outcomes of interest, the low number of trials weakened the external validity of our analysis.

In conclusion, the network meta-analysis ranked the seven treatment methods as follows: plaster fixation, non-bridging external fixation, bridging external fixation, dorsal plating, volar plating, dorsal and volar plating and K-wire fixation. Among these methods, we also found that plaster fixation and non-bridging external fixation are more effective in reducing the risk of CRPS in DRF patients, suggesting that plaster fixation and non-bridging external fixation might be better choices for treatment of DRFs.

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Conflict of interest

The authors declare no conflict of interest.

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