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Research Article

A Meta-Analysis of Distal Radial Fractures Comparing Closed Reduction and Pinning Fixation with Open Reduction and Internal Fixation

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Abstract

Introduction: Distal Radial Fractures (DRF) are one of the most common fractures in the world, and both Pinning with cast or supplementary external fixation and internal fixation especially plating were widely used. We asked (1) does plating shows superior to pinning in functional recovery, clinical outcomes and complication rate; (2) does supplementary external fixation help improve the outcomes of pinning.

Methods: Pub Med, EMBASE, Ovid, Scopus and ISI Web of Science were searched, using the search strategy of "(distal radial fractures OR distal radius fractures OR colles fractures OR smith fractures OR wrist injuries) and (plate OR plating) and (pinning OR pins)". All randomized controlled trials (RCTs) comparing functional recovery, clinical outcomes, radiological measurement and complications between pinning and plating for DRF were identified.

Result: ten of 5287 literatures with 601 patients were included. Plating showed better functional recovery at 3 ($P< 0.0001$), 6 ($P< 0.0001$) and 12 ($P= 0.0002$) months. Cast showed superiority compared with external fixation in DASH score at 12 months ($p= 0.05$). Plating showed lower infection rate ($P= 0.0001$), but higher secondary surgical rate ($P= 0.0004$) and longer operation time ($P< 0.00001$). Pinning showed a better result in ulnar variance ($P= 0.01$). We found significant difference in grip strength at 3 months in favor of plate ($P< 0.0001$), but the opposite result at 12 months ($P< 0.00001$). Plating showed better result in extension, flexion, supination, ulnar deviation at 3 months ($P< 0.05$), but worse result in extension and ulnar deviation at 6 and 12 months and flexion at 12 months ($P< 0.05$).

Conclusions: With better functional recovery and lower infection rate, open reduction and internal fixation with locking plate is preferential to closed reduction and pinning fixation. Cast is preferred as the supplementary fixation for pinning if there is no need for supplementary external fixation. However, more RCTs with high quality are needed to prove our conclusion.

Keywords: Pinning; Plating; Distal radial fractures; External fixation

Introduction

Distal Radial Fractures (DRF) are one of the most common fractures in the world, and the incidence is about 0.26% which is also on the increase [1,2]. It accounts for nearly 17% of all fractures in emergency room [3]. The DRF, especially unstable displaced DRF, are needed to get anatomical reduction and fixation as soon as possible. The instability and tissue injury also affect the recovery of radio carpal and radio ulnar joint, which ultimately lead to loss of grip strength and range of motion [4,5]. Current treatments of DRF are mainly focused on pinning fixation with cast or external fixation and internal fixation. The external fixation without pins usually acts as a temporary reduction and fixation technique to make it more convenient for the next operation [4].

The closed reduction and pinning fixation is the most common surgical technique of DRF in the past [6]. Unfortunately, the pinning fixation with cast sometimes can't maintain enough stability. The technique of external fixation well fills the gap. However, the insertion of pins with mini-incision makes it easier to damage tendon and nerve and the immobilization delayed rehabilitation. The development of intra- and extra focal pinning, ascending pinning, threaded pinning and protective end reduce the incidence of complications such as tendon and nerve injury [4]. Recently, the technique of open reduction and internal fixation, especially dorsal plate and volar plate, becomes more popular than before [7]. The remarkable stability, even in articular fractures, improves the recovery of function [4,8]. Biomechanical experiment in a cadaver model shows plate provides more stability than pins [9]. The mainly disadvantage of plate is the bulkiness in an anatomical zone which raises the possible incidence of tendon injury and tendinitis [4]. And the complaint of the hardware irritation makes patient more likely to undergo a secondary surgery to remove it [6].

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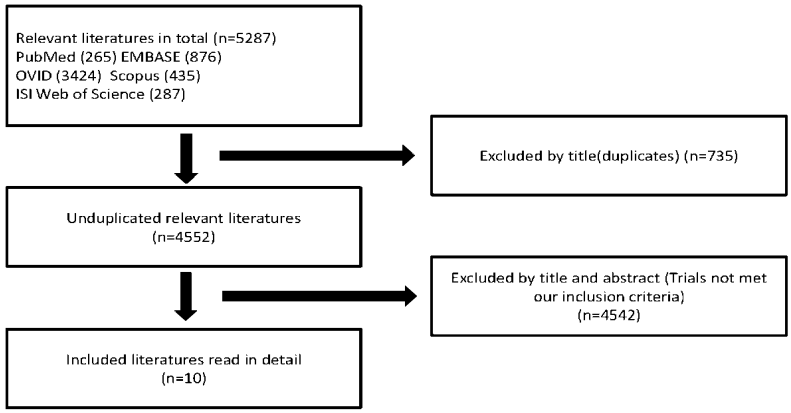

Figure 1: The specific selection procedure applied in our meta-analysis.

Table 1: Study characteristics and interventions.

Study	Design	Sample size (plate/ pinning)	Age (years)	Gender (male %)	Follow-up(month)	Loss to follow up	AO classification	Supple-mentary fixation	Plate	Inclusion criteria
Dzaja I [10]	RCT	24/20	50.3 (14.7)/40.3 (12.4)	29.2%/25%	12	0/0	A,C1	Cast	Volar	AO type A extra-articular or type C1 simple intra-articular DRFs treated with either percutaneous k-wire ixation or VLP individuals. in skeletally mature
Hollevoet N [11]	RCT	20/20	67/66	10%	>12	4/5	A,B,C	Cast	Volar	men and women at least 50 years old who had sustained a dorsally displaced fracture of the distal radius following a simple fall
Marcheix PS [12]	RCT	53/55	75 (11)/ 73 (11)	24%/9%	7	3/2	A2,A3,C2,C3	Cast	Volar	All patients aged 50 years or more, with a dorsally displaced fracture of the distal radius, whether intra- or extra-articular, and with or without a distal ulna fracture
McFadyen I [13]	RCT	27/29	61 (26-80)/ 65 (18-80)	44%/38%	6	0/0	A	Cast	Volar	Patients with closed, unilateral, dorsally displaced, unstable extra-articular distal radius fractures
Rozental DT [14]	RCT	23/22	51 (19-77)/ 52(24-79)	30%/19%	12	2/1	A2,A3,C1,C2	Cast	Volar	Consecutive patients presenting to the outpatient ortho-paedic clinic with dorsally displaced fractures of the distal part of the radius
Egol K [15]	RCT	44/44	52.2 (19-87)/49.9 (18-78)	43%/50%	12	5/6	A,B,C	External fixation	Volar	a fracture of the distal radius requiring operative repair amenable to either open reduction and internal fixation or external fixation and Kirschner (K)-wires
Gradl G [16]	RCT	52/50	63 (18-88)	13%	12	0/0	A3,C1,C2,C3	External fixation	Volar	dorsally displaced (>20°) extra-articular A3 and intra-articular C1–C3 fractures
Grewal R [17]	RCT	29/33	46 (2.7)/ 45(2.7)	41%/64%	18	0/0	C1,C2,C3	External fixation	Dorsal	skeletal maturity, age less than 70 years, and intra-articular distal radius fractures with 2 mm or more of intra-articular step deformity on either prereduction or postreduction radiographs
Grewal R 2011 [18]	RCT	27/26	58 (9.9)/ 53.8 (11.7)	23%/25%	12	1/2	A,C1,C2,C3	External fixation	Volar, dorsal	Patients with unstable distal radius fractures requiring surgery
Wei DH [19]	RCT	22/12	61 (18)/ 55 (16)	25%/27%	18	0/0	A,C	External fixation	Volar	All patients who were at least eighteen years of age and had an unstable distal radial fracture were invited to participate in the study

The best surgical method for unstable displaced DRF is still controversial. Nowadays, a large amount of trials focus on the surgical choice for DRF comparing pinning to plating is done [10-19]. We included all Randomized Controlled Trials (RCTs) to find the answer to: (1) does plating shows superior to pinning in functional recovery, clinical outcomes and complication rate; (2) does supplementary

Table 2: Methodological quality of the included studies based on the 12-items scoring system.

Study	Randomized adequately*	Allocation concealed	Similar baseline	Patient blinded	Care provider blinded	Outcome assessor blinded	Avoided selective reporting	Similar or avoided cofactor	Patient compliance#	Acceptable drop-out rate$	Similar timing	ITT analysis&	quality+
Dzaja I [10]	Yes	Yes	No	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	No	Moderate
Hollevoet N [11]	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	No	Yes	No	Moderate
Marcheix PS [12]	Yes	Yes	Yes	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	No	High
McFadyen I [13]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Rozental DT [14]	Yes	Yes	Yes	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	No	High
Egol K [15]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	No	High
Gradl G [16]	Yes	Yes	Yes	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	High
Grewal R [17]	Yes	Yes	Yes	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	No	High
Grewal R 2011 [18]	Yes	Yes	Yes	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	No	High
Wei DH [19]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High

*Only if the method of sequence generated was explicitly described could get a ''Yes''; sequence generated by ''Dates of Admission'' or ''Patients Number'' received a ''No''; # intermittent treatment or therapy duration less than 6 months means ''Yes'', otherwise ''No''; $ drop-out rate > 20% means ''No'', otherwise ''Yes''; & ITT = intention-to-treat, only if all randomized patients are analyzed in the group they were allocated to could receive a ''Yes''; + ''Yes'' items greater than 7 means ''High''; greater than 4 but no more than 7 means ''Moderate''; no more than 4 means ''Low''.

external fixation help improve the outcomes of pinning.

Materials and Methods

Two reviewers (XHX and AL) searched Pub Med (1966 to March 2014), EMBASE (1974 to March 2014), Ovid (1966 to March 2014), Scopus (1966 to March 2014), ISI Web of Science (1945 to March 2014), using the search strategy of "(distal radial fractures or distal radius fractures or colles fractures or smith fractures or wrist injuries) and (plate or plating) and (pinning or pins)", with no limitation of publication year or language. All the related reference lists in included literatures were read in depth in order to find any literatures met our inclusion criteria.

Inclusion criteria and exclusion criteria

The inclusion criteria and exclusion criteria were strictly defined before document retrieval. The inclusion criteria: (1) DRF (whether extra-articular or intra-articular) was involved, (2) adult (age > 18), (3) the comparison between plating and pinning was adopted, (4) functional score, complication rate, radiological measurements, range of motion or grip strength was assessed, and (5) the design was RCT. Literatures were excluded if: (1) diaphyseal fractures or metacarpal fractures were involved, (2) Neither of the outcomes was available, (3) the follow-up of studies was less than 3 months, and (4) not a comparison study between plating and pinning. According to our inclusion criteria and exclusion criteria, all the publications which didn't meet our criteria were excluded. The selection procedure was described in detail in (Figure 1).

Data extraction: Two reviewers (XHX and PG) separately extracted the data of study characteristics and intervention from included literatures and checked the correctness together (Table 1). We focused on the study design, sample size, age, gender, follow-up period, loss to follow-up, fracture classification of DRF, supplementary fixation, inclusion criteria. All the included literatures were randomized controlled trials. Most of the studies were small-scaled with sample size ranging from 40-70. The total sample size was 601 (plate group: 296; pinning group: 305). As for pinning fixation, half of the included literatures adopted cast as the supplementary fixation [10-14], while the other half chose external fixation [15-19]. Intention-To-Treat (ITT) analysis was used whenever it is possible.

The outcomes included DASH score, complication rate, secondary surgery rate, operation time, radiological measurements, range of motion and grip strength. The complications contained infection, tendon rupture, tendonitis, nerve deficit, Complex Regional Pain Syndrome (CRPS) and Carpal Tunnel Syndrome (CTS). Besides, radiological measurements included volar tilt, radial inclination, radial length and ulnar variance. We also analyzed range of motion (extension, flexion, supination, pronation, ulnar deviation and radial deviation) in two ways (percentage of uninjured side and degree). Except the complication rate and radiological measurement, all the outcomes were analyzed separately in 3, 6, 12 months. The data of complication rate was extracted at the end of follow-up period. We also used subgroup analysis of supplementary fixation (cast and external fixation) to analyze our outcomes.

Methodological quality

Two reviewers (XHX and YLC) assessed the methodological quality of literatures according to the 12-item scale [20], which contained randomized adequately, allocation concealed, similar baseline, patient blinded, care provider blinded, outcome assessor blinded, avoided selective reporting, similar or avoided cofactor, patient compliance, acceptable drop-out rate, similar timing and ITT analysis (Table 2). Inconsistent opinions were judged by another author (SGY). Disagreement was evaluated by means of kappa (κ) test and resolved by discussion. All the included trials were RCTs. The most severe question was the blinded method. ITT analysis was used in three trials [13,16,19]. The weighted kappa for the agreement on the trial quality between reviewers was 0.87 (95% CI, 0.79–0.95).

Statistical analysis

We used Review Manager 5.1.3 software to convert all outcome measurements and all the operation was based on Cochrane handbook. We used Relative Risk (RR) for dichotomous data and

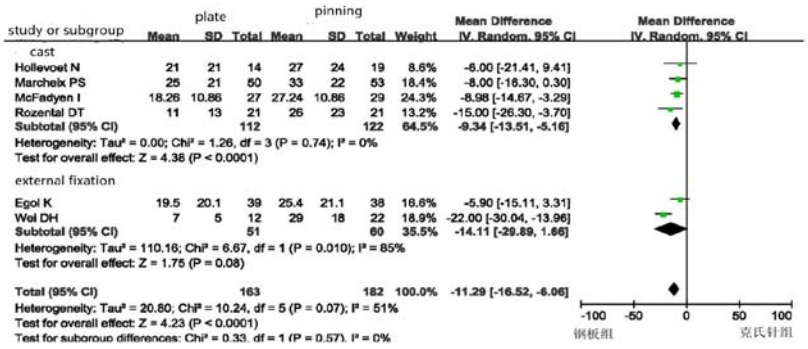

Figure 2: Forest plot for DASH score at 3 months between plating and pinning showed plating was superior to pinning with higher functional score. DASH = Disabilities of the Arm; Shoulder and Hand; WMD = Weighted Mean Difference.

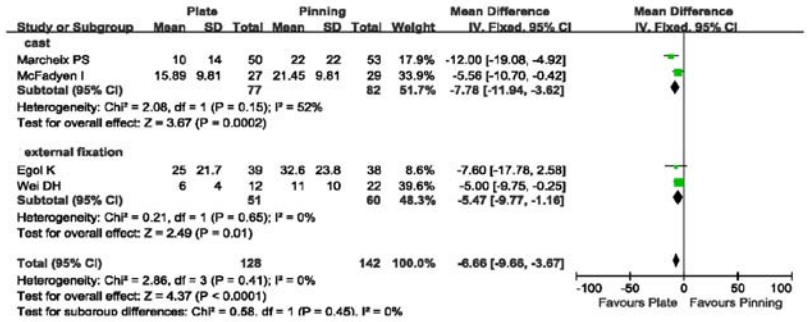

Figure 3: Forest plot for DASH score at 6 months between plating and pinning showed plating was superior to pinning with higher functional score. DASH = Disabilities of the Arm; Shoulder and Hand; WMD = Weighted Mean Difference.

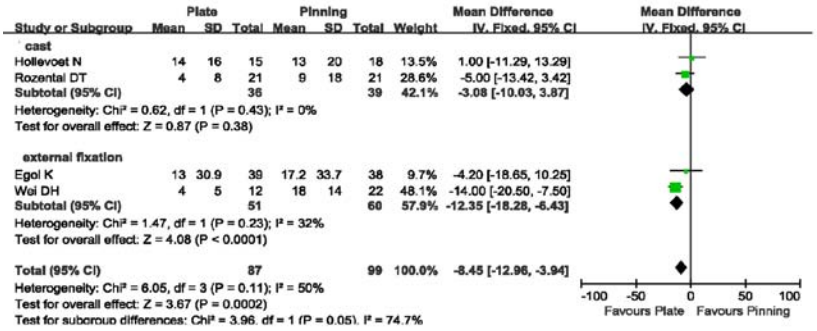

Figure 4: Forest plot for DASH score at 12 months between plating and pinning showed plating was superior to pinning with higher functional score. DASH = Disabilities of the Arm; Shoulder and Hand; WMD = Weighted Mean Difference.

Weighted Mean Difference (WMD) for continuous data. A Chi-squared test on N-1 degrees of freedom was used to calculate the statistical heterogeneity, with significance at 0.05. I^2 (I^2 = [(Q-df)/Q] x 100%) was used to calculate the percentage of the variability in effect estimates according to the heterogeneity. Q is the χ^2 statistic and df is the degree of freedom. A fixed effects model was used if I^2 was no more than 50%; otherwise, we used the random effects model. If substantial heterogeneities across studies (I^2>50%) were detected in the index five main meta-analysis in DASH score, complication rate, radiological measurement and clinical outcomes, we performed post hoc sensitivity analysis or subgroup analysis to determine the sources of heterogeneity. The heterogeneity of operation time was not be analyzed because it didn't matter in our analysis. The outliers were detected as the studies of which the confidence interval of the estimated effect size did not well overlap with the pooled overall effect size [21]. It is recognized that tests for funnel plot asymmetry needn't be done unless the included trials in the outcomes of meta-analysis are at least 10. None of DASH scores at different time points have included at least 10 studies. Even when the funnel plot is done, the power is too low to distinguish chance from real asymmetry [20,22]. As a result, we didn't make funnel plot to analyze the publication bias. When allowed, subgroup analysis of supplementary fixation was performed for DRF. We also used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system to

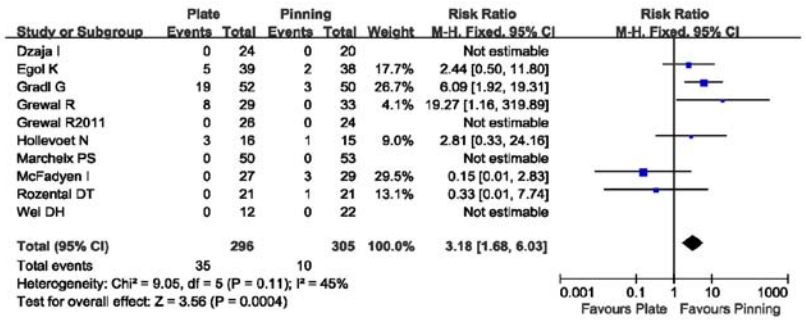

Figure 5: Forest plot for secondary surgery rate between plating and pinning showed pinning was superior to plating with lower secondary surgery rate. RR= Risk Ratio.

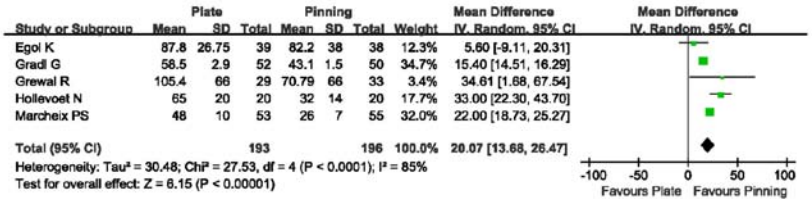

Figure 6: Forest plot for operation time between plating and pinning showed pinning was superior to plating with less operation time. WMD= Weighted Mean Difference.

Table 3: The complication rate and secondary surgery rate between Plating and K-wire.

Outcomes	Group	Event (Plating/K-wire)	Sample size (Plating/K-wire)	RR# (Mean [CI])	I^2	P	P (subgroup)
Infection rate	Cast	1/15	138/138	0.17 [0.05, 0.69]	0%	0.005	
	External fixation	1/12	158/167	0.15 [0.04, 0.65]	0%	0.01	
	Total	2/12	296/305	0.16 [0.06, 0.42]	0%	0.0001	0.88
Tendon rupture rate	Cast	0/1	138/138	0.31 [0.01, 7.15]	N.A.	0.47	
	External fixation	5/3	158/167	1.50 [0.40, 5.63]	0%	0.55	
	Total	5/4	296/305	1.14 [0.36, 3.67]	0%	0.82	0.37
Tendonitis rate	Cast	1/3	138/138	0.42 [0.07, 2.65]	0%	0.35	
	External fixation	10/2	158/167	3.43 [1.08, 10.88]	0%	0.04	
	Total	11/5	296/305	1.93 [0.80, 4.66]	0%	0.15	0.06
Nerve deficit rate	Cast	1/3	138/138	0.49 [0.09, 2.65]	0%	0.4	
	External fixation	10/9	158/167	1.38 [0.59, 3.21]	0%	0.46	
	Total	11/12	296/305	1.08 [0.51, 2.27]	0%	0.84	0.28
CRPS rate	Cast	2/9	138/138	0.30 [0.08, 1.05]	0%	0.06	
	External fixation	4/3	158/167	1.21 [0.31, 4.83]	0%	0.77	
	Total	6/12	296/305	0.54 [0.23, 1.31]	0%	0.17	0.14
CTS rate	Cast	1/3	138/138	0.42 [0.07, 2.71]	0%	0.36	
	External fixation	5/1	158/167	3.71 [0.62, 22.02]	0%	0.15	
	Total	6/4	296/305	1.40 [0.46, 4.30]	0%	0.56	0.1

CRPS = Complex Regional Pain Syndrome; CTS = Carpal Tunnel Syndrome; RR = Relative Risk; #RR > 1 means the results favoring pinning, vice versa.

evaluate the quality of evidence by each outcome.

Results

The selection procedure was described in detail in (Figure 1). Of 5287 relevant studies, 735 were redundant and 4542 studies didn't meet our criteria of inclusion and exclusion. Finally 10 literatures of randomized controlled trials with 601 participants were included. The weighted kappa for the agreement on eligibility between reviewers was 0.84 (95% CI: 0.71-0.93).

Table 4: The radiological measurements, range of motion and grip strength between Plating and K-wire.

Outcomes	Months	Studies	Sample size (Plating/K-wire)	Mean Difference* (Mean [CI])	I^2	P	Favor	P (subgroup&)	Favor (subgroup)
1.Radiological measurement		7	195/203	0.40 [-4.72, 5.53]	96%	0.88			
Volar tilt	12							0.37	
Radial inclination	12	6	143/153	-0.38 [-1.92, 1.16]	72%	0.63		0.29	
Radial length	12	4	101/114	-0.49 [-1.23, 0.26]	0%	0.2		0.32	
Ulnar variance	12	5	125/141	-0.74 [-1.33, -0.15]	13%	0.01	Pinning	0.14	
2.Range of motion (%)#									
Extension (%)	3	3	67/79	8.58 [3.64, 13.52]	22%	0.0007	Plate	0.11	
	6	3	103/110	-3.05 [-3.77, -2.33]	20%	<0.00001	Pinning	N.A.	
	12	5	148/158	-2.26 [-2.88, -1.64]	33%	<0.00001	Pinning	0.15	
Flexion (%)	3	3	67/79	4.11 [-1.03, 9.25]	46%	0.12		0.51	
	6	3	103/110	4.96 [-9.59, 19.52]	94%	0.5		N.A.	
	12	5	148/158	-4.34 [-5.14, -3.54]	19%	<0.00001	Pinning	0.05	EF
Supination (%)	3	3	67/79	6.01 [0.41, 11.61]	32%	0.04	Plate	0.09	
	6	3	103/110	1.80 [-2.53, 6.13]	57%	0.42		N.A.	
	12	5	148/158	-1.59 [-4.20, 1.03]	51%	0.23		0.726	
Pronation (%)	3	3	67/79	2.55 [-8.36, 13.46]	85%	0.65		0.71	
	6	3	103/110	11.62 [-4.91, 28.14]	98%	0.17		N.A.	
	12	5	148/158	1.25 [-0.83, 3.33]	71%	0.24		0.36	
Ulnar deviation (%)	3	3	67/79	0.36 [-3.14, 3.87]	16%	0.84		0.36	
	6	3	103/110	-3.22 [-4.16, -2.28]	49%	<0.00001	Pinning	N.A.	
	12	5	148/158	-0.84 [-1.67, -0.02]	0%	0.05	Pinning	0.77	
Radial deviation (%)	3	3	67/79	8.22 [-17.19, 33.63]	93%	0.53		0.91	
	6	3	103/110	-5.83 [-21.57, 9.91]	97%	0.47		N.A.	
	12	5	148/158	-2.01 [-4.95, 0.93]	85%	0.18		0.62	
3.Range of motion (deg)									
Extension (deg)	3	3	97/98	3.79 [0.39, 7.20]	43%	0.03	Plate	0.36	
	6	2	76/77	0.24 [-5.62, 6.10]	53%	0.94		0.14	
	12	2	47/45	-2.80 [-7.82, 2.22]	0%	0.27		0.88	
Flexion (deg)	3	3	97/98	4.85 [0.62, 9.08]	9%	0.02	Plate	0.22	
	6	2	76/77	4.06 [-0.38, 8.50]	0%	0.07		0.38	
	12	2	47/45	-4.63 [-9.96, 0.70]	0%	0.09		0.86	
Supination (deg)	3	3	97/98	7.51 [2.12, 12.90]	0%	0.006	Plate	0.88	
	6	2	76/77	7.07 [-0.77, 14.91]	64%	0.08		0.09	
	12	2	47/45	2.67 [-1.08, 6.41]	50%	0.26		0.16	
Pronation (deg)	3	3	97/98	0.13 [-3.28, 3.54]	0%	0.94		0.27	
	6	2	76/77	-1.00 [-2.95, 0.95]	0%	0.31		1	
	12	2	47/45	0.69 [-1.44, 2.81]	26%	0.53		0.24	
Ulnar deviation (deg)	3	2	47/45	3.97 [0.99, 6.95]	0%	0.009	Plate	0.51	
	6	1	26/24	1.00 [-2.63, 4.63]	N.A.	0.59		N.A.	
	12	2	47/45	4.64 [-2.21, 11.49]	63%	0.18		0.1	
Radial deviation (deg)	3	2	47/45	1.19 [-1.31, 3.69]	0%	0.35		0.76	
	6	1	26/24	-2.00 [-4.77, 0.77]	N.A.	0.16		N.A.	
	12	2	47/45	0.76 [-7.94, 9,46]	78%	0.86		0.03	EF
4.Grip strength (%)	3	5	143/156	8.8 [4.46, 13.14]	0%	<0.0001	Plate	0.86	
	6	5	179/187	-1.02 [-10.68, 8.65]	88%	0.84		0.04	EF
	12	6	174/182	-2.87 [-4.04, -1.70]	7%	<0.00001	Pinning	0.47	

deg = degree; N.A.= Not Available; EF= External Fixation; # percentage of uninjured side; Mean Difference < 0 means the results favoring K-wire, vice versa; & the p between subgroup pinning and subgroup plate.

DASH score

We found significant difference of DASH score at 3 months (N=345, MD: -11.29 [-16.53, -6.05]; P< 0.0001), 6 months (N=270, MD: -6.66 [-9.66, -3.67]; P< 0.0001) and 12 months (N=186, MD: -8.45 [-12.96, -3.94]; P= 0.0002) in favor of plating (Figure 2-4). There existed heterogeneity in the result of DASH score at 3 months (I_2= 51%) and 12 months (I_2= 50%). When excluded Wei DH et al [19], the heterogeneity disappeared in both (I_2= 0%). The data of Wei DH et al seemed to be an outlier. It might be caused by the mismatch of sample size in each group (group plate: 12; group pinning: 22). With the subgroup analysis of supplementary fixation, we found cast showed superiority compared with external fixation in DASH score at 12 months (p= 0.05).

Complication rate, secondary surgery rate and operation time

Among the complication rate (Table 3), plating showed lower infection rate (N=601, RR: 0.16 [0.06, 0.42]; P= 0.0001). The subgroup analysis didn't show any difference between cast and external fixation in complication rate. However, we found plating showed a higher secondary surgery rate compared to pinning which was mostly related to implant remove (N=601, RR: 3.18 [1.68, 6.03]; P= 0.0004) (Figure 5), and pinning cost less operation time (N=389, RR: 20.07 [13.68, 26.47]; P< 0.00001) (Figure 6). The heterogeneities were all acceptable except for the operation time (I^2= 85%).

Radiological measurements, range of motion and grip strength

Of radiological measurements (Table 4), we found pinning showed a better result in ulnar variance (N=266, RR: -0.74 [-1.33, -0.15]; (P= 0.01), but no significant difference in volar tilt, radial inclination and radial length. We found significant difference in grip strength at 3 months in favor of plate (N=299, RR: 8.8 [4.46, 13.14]; P< 0.0001), but the opposite result at 12 months (N=356, RR: -2.87 [-4.04, -1.70]; P< 0.00001). No heterogeneities were observed in outcomes mentioned above.

We found plating showed better extension (percentage: N=146, RR: 8.58 [3.64, 13.52]; P= 0.0007; degree: N=195, RR: 3.79 [0.39, 7.20]; (P= 0.03), better flexion (degree: N=195, RR: 4.85 [0.62, 9.08]; P= 0.02), better supination (percentage: N=146, RR: 6.01 [0.41, 11.61]; P= 0.04; degree: N=195, RR: 7.51 [2.12, 12.90]; (P= 0.006) and better ulnar deviation (degree: N=92, RR: 3.97 [0.99, 6.95]; P= 0.009) at 3 months. On the contrary, the extension (percentage at 6 months: N=213, RR: -3.05 [-3.77, -2.33]; P< 0.00001; percentage at 12 months: N=306, RR: -2.26 [-2.88, -1.64]; P<0.00001) and ulnar deviation (percentage at 6 months: N=213, RR: -3.22 [-4.16, -2.28]; P< 0.00001; percentage at 12 months: N=306, RR: -0.84 [-1.67, -0.02]; (P= 0.05) at 6 months and 12 months were opposite. The flexion at 12 months also was in favor of pinning (percentage: N=306, RR: -4.34 [-5.14, -3.54]; P< 0.00001). All the heterogeneities mentioned above were acceptable (Table 4).

GRADE analysis

Our GRADE analysis (Table 5) showed the moderate quality in all the outcomes. The most important reasons for the reduced level of evidence were inadequate blinding and little sample size.

Discussion

Our meta-analysis is the first meta-analysis to include all RCTs comparing pinning with supplementary cast or external fixation to plating. Recently, one previous systematic review [23], included 5 RCTs, which contained 4 trials comparing pinning with supplementary cast to volar locking plate and 1 trial comparing

Table 5: GRADE evidence of comparison between plate and K-wire in efficacy and safety for treatment of DRF.

Quality assessment						
Outcome	Limitations*	Inconsistency#	Indirectness	Imprecision$	Others&	Quality
DASH score (3 months)	Serious	Serious	No serious	Serious	None	Moderate
DASH score (6 months)	Serious	No serious	No serious	Serious	None	Moderate
DASH score (12 months)	Serious	Serious	No serious	Serious	None	Moderate
Infection rate	Serious	No serious	No serious	No serious	None	Moderate
Tendon rupture rate	Serious	No serious	No serious	No serious	None	Moderate
Tendonitis rate	Serious	No serious	No serious	No serious	None	Moderate
Nerve deficit rate	Serious	No serious	No serious	No serious	None	Moderate
CRPS rate	Serious	No serious	No serious	No serious	None	Moderate
CTS rate	Serious	No serious	No serious	No serious	None	Moderate
Secondary surgery rate	Serious	No serious	No serious	No serious	None	Moderate
Grip strength (%)	Serious	Both+	No serious	Serious	None	Moderate
Radiological measurement	Serious	Both+	No serious	Serious	None	Moderate
Range of motion (%)	Serious	Both+	No serious	Serious	None	Moderate
Range of motion (deg)	Serious	Both+	No serious	Serious	None	Moderate

GRADE = Grading of Recommendations Assessment; Development and Evaluation; RR = Risk Ratio; WMD = Weighted Mean Difference;* inadequate blinding, lack of allocation concealed may cause limitations; # inconsistent report of outcomes and significant heterogeneity, but we used subgroup analysis to explain them; $ a study with wide confidence interval around the estimate of the effect, or included sample less than 400, it would cause imprecision; &"Other" included publication bias and upgraded quality of evidence (large effect, plausible residual confounding and dose-response gradient); + the outcomes of grip strength, radiological measurement and range of motion contain many sub items, such as grip strength contains 3,6 and 12 months and radiological measurement contains volar tilt, radial inclination, radial length and ulnar variance. Parts of the outcomes are serious and others are not serious, but all the outcomes get the moderate quality.

pinning with supplementary external fixation to volar locking plate. It made the conclusion that plating showed better functional recovery in earlier time, but no difference was found in the long term. The limited sample size and lack of meta-analysis made the conclusion not persuasive. With increased sample size and meta-analysis in our literature, the conclusion was more reliable. The subgroup analysis of supplementary fixation made our meta-analysis stricter.

However, there still existed some limitations: (1) The sample size of particular outcomes was still low, such as DASH score at 6 months, DASH score at 12 months and range of motion. We made every effect to search for literatures related to our topic. The sample size was the largest at present and future RCTs were needed. (2) There existed significant heterogeneity in the outcomes of DASH score at 3 months, radiological measurement, grip strength and range of motion. Sensitive analysis and subgroup analysis were done to find the origins. (3) Publication bias was not assessed in our meta-analysis related to the lack of 10 included literatures in DASH score. So we didn't make funnel plot related to the method of meta-analysis [20,22].

The principal discovery was that open reduction and internal fixation of locking plate showed superior to closed reduction and pinning fixation in DASH score at 3, 6 and 12 months, which might be related to the better reduction and earlier mobilization [4,7,24]. It was more suitable for active patients who required earlier return to work compared with elderly patients. For patients with osteoporosis, pinning was more difficult to maintain reduction which was against the functional recovery [25].

Furthermore, all the complication rates were comparable except for the infection rate which was more frequently happened in group pinning. The infections in group pinning also were not severe and were treated with antibiotics successfully [10-15,17-18]. The complications in each literature were mainly about tendon and nerve injury, except for infection. However, the amount of complications was not large compared with the whole sample size. The mini-incision made it hard for the procedure of pins insertion to avoid nerve or tissue injury. More patients treated with plating were likely to undergo a secondary surgery which mainly was consisted of implant remove. It is also common in other fractures treated with plating which was probably due to hardware irritation [4,6]. Drobetz H et al advised patient undergoing plating should remove the plate at 4 months after operation in order to avoid tendon ruptures [26]. But we couldn't regard the implant remove as a conventional treatment unless the implant reduced the quality of life. We also found plating acquire more operation time which obviously increased the operation fee.

The superiority of plating in clinical outcomes disappeared over time. Furthermore, pinning showed better in extension and ulnar deviation at 6 and 12 months, so as flexion and grip strength at 12 months. Pinning seemed to be better for the clinical recovery in the long-term follow up. The anatomical reduction in plating turned to be useless in the long-term follow up. This might be due to the delayed mobilization which was helpful for the linear and positional alignment of fracture ends [27]. Further research needed to be done to clarify the truth.

In our meta-analysis, we included both pinning with cast and pinning with external fixation. Subgroup analysis of supplementary fixation was done to find out whether the supplementary external fixation was benefit for pinning fixation. We found external fixation didn't improve the effect of pinning, but do harm to the functional recovery at 12 months. It cost more time until weight bearing mobilization which would reduce the stimulation of mechanical stress in pinning with external fixation. This was adverse to the fracture union and functional recovery [7,28]. The additional damage of external fixation also might cause more complications which also were against functional recovery6. But it was not reflected in our meta-analysis. However, supplementary external fixation was necessary sometimes when adequate stability couldn't be acquired after pinning fixation [4,6]. With improved stability [4,7], it was helpful for the recovery of grip strength at 6 months, flexion at 12 months and radial deviation at 12 months. Although grip strength at 6 months was in favor of external fixation, it didn't differ at 12 months which meant external fixation didn't show any superiority of grip strength recovery in the long-term follow up. Better radiological measurement was acquired by external fixation, but it got less attention than functional recovery. When both supplementary fixations could be chosen, it's better to choose cast as supplementary fixation.

Our meta-analysis was a further search of the previous systematic review [23]. The previous systematic review found plating resulted in early functional recovery but this advantage disappeared in the long-term follow up. We not only demonstrated the benefit of plating in early functional recovery once again, but also found it still existed in the long-term follow up.

What's more, plating showed lower infection rate and other complication rates were comparable between two techniques. But plating still had several faulty, such as the recovery of radiological measurement and clinical outcomes in the long-term follow up, higher secondary surgery rate and longer operation time. Pinning with cast was more suitable in order to acquire better function recovery in the long-term follow up compared with pinning with external fixation.

Conclusion

With better functional recovery in the short-term or long-term follow up, lower infection rate and other comparable complication rates, open reduction and internal fixation with locking plate is preferential to closed reduction and pinning fixation. When there is no necessity of the supplementary external fixation, we choose pinning with cast firstly as the better functional recovery in the long-term follow up. However, more RCTs with high quality are needed to prove our conclusion.

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