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Original article

Prosthesis replacement in Mason III radial head fractures: A meta-analysis

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ABSTRACT

Introduction: This present study was to evaluate the clinical efficacy of prosthesis replacement (PR) for patients with Mason III radial head fractures (RHF) compared with open reduction and internal fixation (ORIF).
Methods: We retrieved the relevant trials up to September 2013 from several public databases, mainly including PubMed, Embase, Springer, Elsevier Science Direct, Cochrane Library, Google scholar, CNKI and Wanfang database. Weighted mean difference (WMD) or odds ratio (OR) and their 95% confidence intervals (CI) were calculated to compare the clinical outcomes between PR and ORIF.
Results: A total of 9 studies including 365 patients with Mason III RHF (169 patients treated with PR and 196 patients treated with ORIF) were reanalyzed in the meta-analysis. The results showed that the patients with Mason III RHF receiving PR, compared with the ORIF ones, had a significantly higher percentage of postoperative excellent and good rate (OR = 3.48, 95% CI = 1.98 to 6.11, $P < 0.0001$), better Broberg and Morrey elbow scores (WMD = 9.79, 95% CI = 4.22 to 15.36, $P = 0.0006$) and significantly lower postoperative complications (OR = 0.33, 95% CI = 0.16 to 0.69, $P = 0.003$).
Conclusions: Although the results of this study supported the use of PR in the treatment of Mason III RHF in Chinese population with short-term outcomes, the evidences are of low quality and further studies were required for confirming these results in the longer term on other populations.
Level of evidence: Level III. Low power meta-analysis.

1. Introduction

Radial head fractures (RHF) are the most common fractures in elbow, which account for an estimated 25% to 44% of all elbow fractures and 1.7% to 5.4% of all fractures in adults [1], and frequently associated with ligamentous, cartilaginous, or other bony injuries [2]. Mason classified RHF into three types:

- type I, fissure fracture or marginal fracture without displacement;
- type II, marginal sector fracture with displacement;
- type III, comminuted fractures involving the entire head [3].

For type I fractures, the conservative treatment is suitable in early mobilization; type II fractures can be treated conservatively or using open reduction and internal fixation (ORIF), depending on the fragment size and dislocation [4]. As type III fractures become more comminuted, the treatment also becomes more challenging. Considering the high complication rate of excision, ORIF and prosthesis replacement (PR) have become the most advocated treatment options for Mason type III fractures currently [5–9]. However, which one is the ideal treatment method continues to be a subject of debate [10].

Recently, many previous studies have compared the clinical outcomes of ORIF and PR for type III fractures [9,11,12]. For example, Ruan et al. and Chen et al. reported that PR was better than ORIF in treatment of Mason type III RHF [9,11]. However, Zhang et al. recommend the preference of ORIF [13]. Given these inconsistent conclusions, we could not confirm the better clinical efficacy of PR than ORIF for Mason type III RHF. Thus, we conducted this meta-analysis with relevant studies to systemically compare the clinical outcomes between ORIF and PR for Mason III RHF.

2. Methods

The meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.

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2.1. Data sources

We retrieved the relevant trials up to November 2014 from several public databases, mainly including PubMed, Embase, Springer link, Elsevier Science Direct, Cochrane Library, Google scholar, CNKI (China National Knowledge Infrastructure, in Chinese) and Wanfang database (in Chinese). The key words of "open reduction", "internal fixation", "artificial radial head replacement", "Mason type III", "radial head replacement" or "radial head fractures" were used for searching. Meanwhile, references from retrieved papers were checked for additional studies.

2.2. Inclusion and exclusion criteria

The included studies should meet the following criteria:

- the participants were patients with Mason III RHF;
- the studies were controlled clinical trials (CCTs) or randomized control trials (RCTs);
- comparison between PR (PR group) and ORIF (ORIF group) were investigated;
- Broberg and Morrey elbow score, postoperative excellent and good rate or complications were evaluated.

Meanwhile, sample size and age of participants were not limited. There was no language limitation in the inclusion criteria.

The studies were excluded when:

- they were reviews, reports, or duplicated publications;
- the comparison between case and ORIF group was not performed;
- there was no access to obtain the full text.

2.3. Quality assessment and data extraction

Two investigators extracted data independently using the pre-designed standard protocol. Discrepancies were resolved by discussion until consensus was reached or contacting with the authors of the included studies to obtain further information. We recorded the first author's name, year of publication, sample size, study design, duration of follow up, gender and age of participants in PR and ORIF group.

We assessed the risk of bias in the included studies using the criteria with 12 items, which was recommended by Furlan et al. [14]. Each item was assigned one score when a response of "yes" was obtained, while there was no score for "no" and "unclear". The quality of studies was judged "high" with over 7 scores, "moderate" with 5 to 7 scores and "low" with less than 5 scores.

2.4. Meta-analysis methods

The meta-analysis was performed using the software of Review Manager 5.1 (Cochrane Collaboration, http://ims.cochrane.org/revman). Overall weighted mean difference (WMD) or odds ratio (OR) and their 95% confidence intervals (CI) were calculated to compare the clinical outcomes between PR and ORIF. We assessed the within- and between-study variation or heterogeneity by testing Cochran's Q-statistic [15]. Meanwhile, we also quantified the effect of heterogeneity by using I^2-statistic [16]. A significant Q-statistic ($P < 0.10$) or I^2-statistic ($I^2 > 50\%$) indicated significant heterogeneity among the studies, and then the DerSimonian and Laid method in the random effects model was used to pool data [17]. Otherwise, the Mantel–Haenszel method in fixed effects model was used [18]. The significance of the pooled OR or WMD was determined using a Z-test with $P < 0.05$.

2.5. Evaluation of publication bias

Evaluation of publication bias was performed using the STATA package v.11.0 (Stata Corporation, College Station, TX, USA). We evaluated the publication bias using Egger's linear regression test [19], which measured funnel plot asymmetry by the natural logarithm scale of the effect size. The P value less than 0.05 was considered to be statistically significant.

3. Results

3.1. Characteristics of eligible studies

The PRISMA flowchart for literature search and study selection is shown in Fig. 1. After the initial search, total 584 potentially

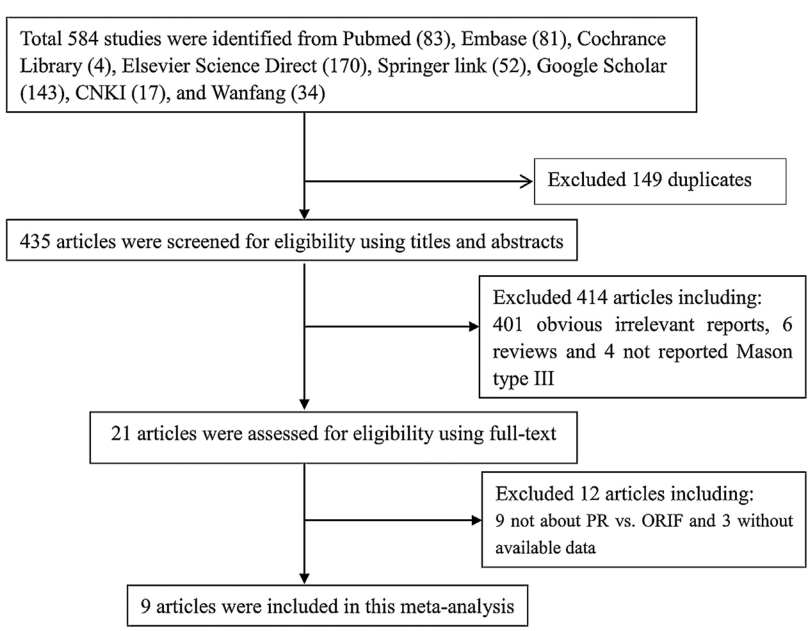

Fig. 1. The flow chart of Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISRM) for literature search and study selection.

relevant studies were identified from the databases. Then, 435 articles were remained after removing duplicates. Among them, 414 of these articles were excluded by scanning titles and abstracts and 12 were excluded by reading the full text according to the inclusion and exclusion criteria. As a result, 9 studies were included in this meta-analysis.

The characteristics of the nine included studies [5,9,11,20–25] are shown in Table 1. The included studies were published between 2006 and 2014. There were two RCTs [9,11] and 7 CCTs [5,20–25]. A total of 365 patients with Mason III RHF (PR group: 169; ORIF group: 196) were reanalyzed in this meta-analysis. All the participants were Chinese people. Some studies reported the combined lesions in patients. The materials and designs of prosthesis in PR group and the fixation approaches in ORIF were different among included studies. In addition, the quality of one included study [11] was considered high with 9 scores, while that of the others was moderate with 5 or 6 scores (Table 2).

3.2. Postoperative excellent and good rate

Postoperative excellent and good rate was investigated in all included studies [5,9,11,20–25]. The heterogeneity test showed that there was no significant heterogeneity among studies (I^2 = 4.0%, P = 0.40), so we used the fixed effects model to pool data. The pooled estimate showed that there were significant differences (OR = 3.48, 95% CI = 1.98 to 6.11, P < 0.0001) in postoperative excellent and good rate between two groups, suggesting that patients received PR had significantly higher postoperative excellent and good rate compared with patients received ORIF (Fig. 2A).

3.3. Broberg and Morrey elbow score

Five included studies [11,20,23–25] reported the Broberg and Morrey elbow score. The heterogeneity test showed that there was significant heterogeneity among studies (I^2 = 94.0%, P < 0.0001), so the random effects model was used. The pooled estimate showed that there were significant differences (WMD = 9.79, 95% CI = 4.22 to 15.36, P = 0.0006) in the Broberg and Morrey elbow score between the two groups, suggesting that PR significantly increased the Broberg and Morrey elbow score of patients compared with ORIF (Fig. 2B).

3.4. Postoperative complications

Eight studies [5,9,11,20,22–25] investigated the postoperative complications. However, no complication was found in each group for the study of Cai et al. [23] and Yang et al. [22]. In the meta-analysis, no evidence for significant heterogeneity among studies was found (I^2 = 0%, P = 0.64), so the fixed effects model was applied. The pooled estimate showed that there were significant differences (OR = 0.33, 95% CI = 0.16 to 0.69, P = 0.003) in postoperative complications between two groups, which suggested that postoperative complications of patients received PR was significantly fewer than that of patients received ORIF (Fig. 2C).

In addition, the complications in each study were shown in Table 3. Among them, the secondary fragment displacement in ORIF group was reported in three studies [9,11,20]. No healing was reported in ORIF group in two included studies [5,11]. Besides, the stiffness caused by prostheses in RP group was reported in two included studies [11,20].

3.5. Evaluation of publication bias analysis

The Egger's linear regression test showed that there was no publication bias in our study (P > 0.05).

4. Discussion

Many studies [11,12,26] have compared the efficacy of PR and ORIF for patients with RHF. However, these studies showed inconsistent results with small sample sizes or low statistical power. In this study, studies were reanalyzed to systemically compare the clinical outcomes of ORIF and PR. The results showed that the patients with Mason III RHF treated by PR had significantly higher postoperative excellent and good rate and Broberg and Morrey elbow score as well as significantly lower postoperative complications compared with that treated by ORIF, which suggested that PR should be preferred for treating Mason III RHF compared with ORIF.

Both ORIF and PR are the usually surgical treatment for Mason III RHF. Although successful treatment of type III fractures with ORIF has been reported in many studies [6,27,28], some studies still recommend the application of PR. Ring et al. advised PR for the 14 patients with a fracture including more than three fragments, in which 10 of them had early failure of fixation or nonunion requiring a second operation to excise the radial head [29]. Nalbantoglu et al. reported that there was a role for PR in comminuted Mason III RHF that cannot reliably be treated with ORIF [6]. Therefore, PR might be more suitable for treating Mason III RHF compared with PR, which may be the reason that contributes to the results of this study.

In addition, the materials of prosthesis were different between studies in this meta-analysis, which may be the reason of inconsistent results among studies. It has been reported that radial head prosthesis comes in a variety of materials and designs, which may affect the clinical outcomes of surgery [13]. Two included studies showed that the stiffness caused by prostheses was occurred in PR group, which used monopolar metal radial head prostheses [11,20]. However, it was not found in included studies with other types of prostheses. Thus, we inferred that the types of prostheses might be the factors of stiffness in these studies. For reducing the complications, the treatment choice for Mason III RHF would consider not only surgical types but also the materials and designs of prostheses. Further studies concerned the materials and designs of prosthesis should be performed for the efficacy assessment of PR.

Some limitations of this study should be noted in this study. First, significant heterogeneity among studies was detected in the analysis of Broberg and Morrey elbow score, further studies must be done to explore the sources of heterogeneity. Second, the confounding factors such as age, sex, combined lesions and sample size were obviously different among the included studies, which may affect the results of meta-analysis. However, there was no enough data to further analyze the influence of these confounding factors on the results of this meta-analysis. Third, the materials of prosthesis and the fixation approaches in ORIF were different among studies, which may affect the results of surgeries. Fourth, the sample size and the number of included studies were small, so that the stability and reliability of the results in this study need more studies with larger sample size to verify. In addition, the region of the included studies was China and only the Chinese population was investigated in these studies. Meanwhile, the clinical outcomes investigated in these studies were all short-term outcomes. Thus, although some evidence for the better efficacy of PR than ORIF for Mason type III RHF were found in this study, we still could not concluded PR was a better treatment than ORIF for Mason type III RHF. More studies with larger sample size were required for further

Table 1
Characteristics of studies included in the meta-analysis.

Study, year	Region	Sample size	Study type	Follow up (months)	Combined lesions		PR group			ORIF group		
							n, M/F	Age (years)	RHP	*n*, M/F	Age (years)	Fixation
Chen [11], 2011	China	45	RCT	33.6 (12–60)	NA		22, NA	37[a] (19–68)	Monopolar titanium	23, NA	37[a] (19–68)	AO mini plate system and K wires
Liu [20], 2010	China	65	CCT	12	PR group: 13 dislocations, 6 ligament lesions, 5 fractures of coronoid process, 3 monteggia fractures	ORIF group: 15 dislocations, 7 ligament lesions, 6 fractures of coronoid process	30, 19/11	32.5 (23–67)	Monopolar metal	35, 21/14	30.7 (21–35)	AO mini plate and screw, K wires
Ma [5], 2011	China	23	CCT	NA	PR group: No combined lesions	ORIF group: 2 fractures of coronoid process, 1 ligament lesion, 2 chick tibial fracture	10, 4/6	43.3[a] (20–75)	Bipolar metal	13, 6/7	43.3[a] (20–75)	AO mini plate and screw, K wires
Ruan [9], 2009	China	22	RCT	15.9 (10–27)	NA		14, 8/6	37.4	Bipolar metal	8, 5/3	40.1	Cannulated screws and K wires
Zhang [21], 2006	China	18	CCT	36 (6–72)	NA		8, NA	NA	Bipolar metal	10, NA	NA	Small T-plate fixation
Chen [24], 2012	China	22	CCT	PR group: 20.2 ± 9.4 ORIF group: 20.5 ± 12.2	8 ligament lesions, 4fractures of coronoid process		11, 6/5	34.7 ± 10.2	Monopolar	11, 7/4	37.7 ± 9.6	T-plate fixation and screw, K wires
Cai [23], 2013	China	72	CCT	PR group: 13.8 ± 1.92 ORIF group: 14.5 ± 1.31	PR group: 4 dislocations	ORIF group: 3 dislocations	37, 19/18	68.7 ± 2.22	NA	35, 19/16	65.5 ± 1.61	Plate and screw
Yang [22], 2013	China	47	CCT	14.5 (10–30)	NA		13	35.6[a] (22–49)	Monopolar	34	35.6[a] (22–49) 14.5 (10–30)	T/L-plate and screw
Wang [25], 2014	China	51	CCT	45.6 (12–84)	NA		24, 13/11	50.7 ± 4.5	Monopolar	27, 16/11	50.0 ± 4.2	AO mini plate

Year: year of publication; RCT: randomized controlled trial; CCT: controlled clinical trial; RHP: radial head prostheses; NA: not available; PR: prosthesis replacement; ORIF: open reduction and internal fixation; K wires: Kirschner wires.

[a] Age of all participants.

Table 2
Quality assessment of the included articles.

Study	Randomised adequately[a]	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[b]	Similar timing	ITT analysis[c]	Scores
Zhang [21]	No	No	Unclear	No	No	No	Yes	Yes	Yes	Yes	Yes	No	5
Ruan [9]	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No	6
Liu [20]	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No	6
Chen [11]	Yes	Unclear	Yes	Yes	No	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	9
Ma [5]	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Unclear	No	5
Chen [24]	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No	6
Cai [23]	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No	6
Yang [22]	No	No	Unclear	No	No	No	Yes	Yes	Yes	Yes	Yes	No	5
Wang [25]	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No	5

[a] Only if the method of sequence generated was explicitly described, they could get a "yes"; sequence generated by "dates of admission" or "patients number" received a "no".
[b] Drop-out rate > 20% means "no", otherwise "yes".
[c] ITT: intention-to-treat, only if all randomized patients are analyzed in the group, they could receive a "Yes".

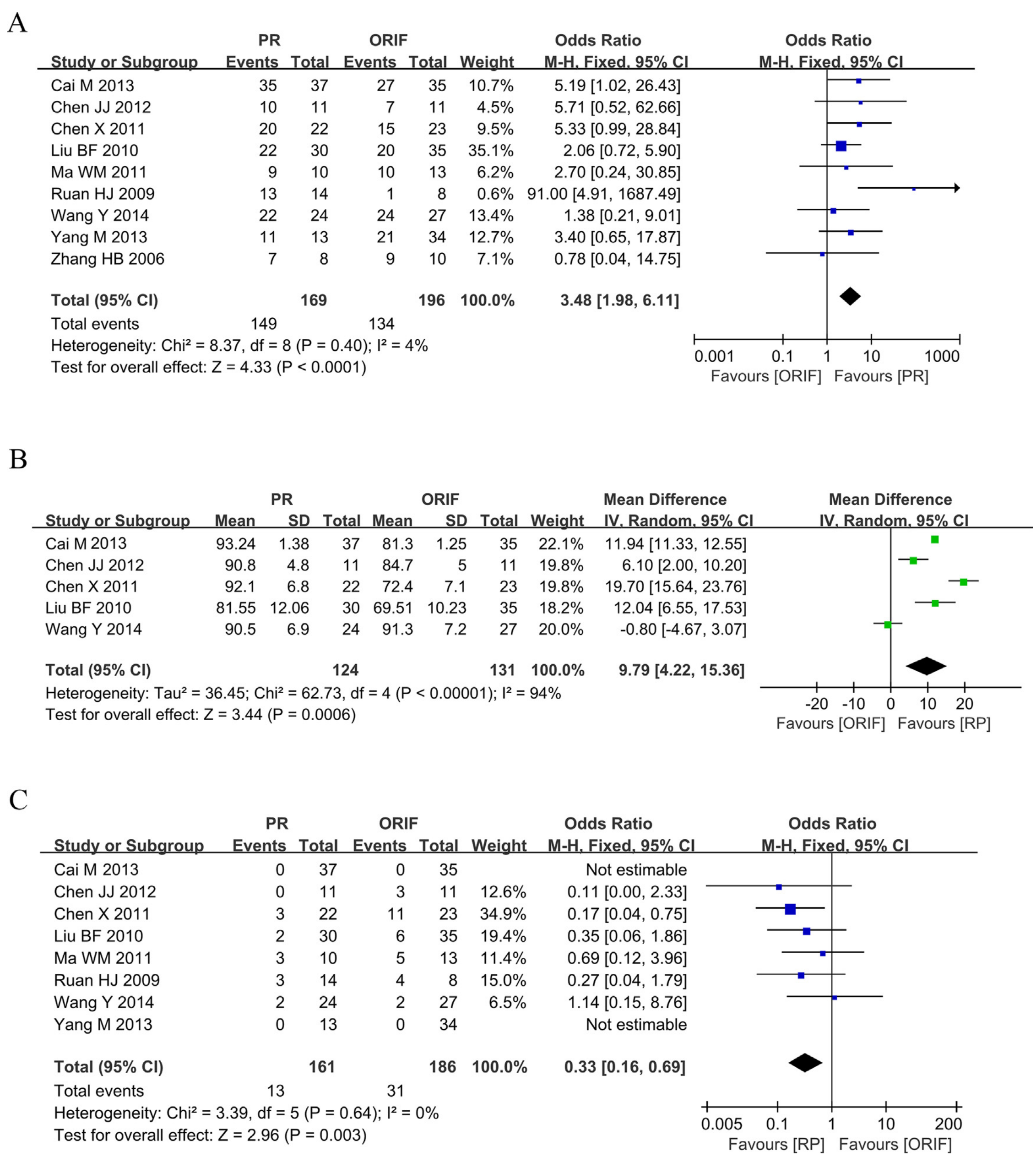

Fig. 2. The forest plots for the postoperative excellent and good rate (A), Broberg and Morrey elbow score (B), and postoperative complication (C). Squares in picture A–C respectively represent the effect size for the odds ratio of the postoperative excellent and good rate, weighted mean difference of Broberg and Morrey elbow score genotypes and the odds ratio of postoperative complication rate. Size of the squares is proportional to the size of the cohorts. Error bars represent 95% confidence intervals (CI). The diamond shape represents the pooled estimates.

Table 3
Complications in each study.

Study	Complications types	PR group n (%)	ORIF group n (%)
Chen [24]	Total sample size	n = 11	n = 11
	Delayed healing	1 (9.1)	0 (0)
	Traumatic arthritis	0 (0)	2 (18.2)
	Total	1 (9.1)	2 (18.2)
Wang [25]	Total sample size	n = 24	n = 27
	Heterotopic ossification	1 (4.2)	0 (0)
	Traumatic arthritis	1 (4.2)	1 (3.7)
	Elbow supination	0 (0)	1 (3.7)
	Total	2 (8.3)	2 (7.4)
Chen [11]	Total sample size	n = 22	n = 23
	Range of motion deficit >30°	2 (9.1)	4 (17.4)
	Stiffness caused by prostheses	1 (4.5)	0 (0)
	No healing	0 (0)	1 (4.3)
	Secondary fragment displacement	0 (0)	3 (13.1)
	Deep wound infection	0 (0)	1 (4.3)
	Heterotopic ossification	0 (0)	2 (8.7)
	Total	3 (13.6)	11 (47.9)
Liu [20]	Total sample size	30	35
	Delayed healing	0 (0)	2 (5.7)
	Heterotopic ossification	0 (0)	2 (5.7)
	Secondary fragment displacement	0 (0)	2 (5.7)
	Range of motion deficit >30°	1 (3.3)	0 (0)
	Stiffness caused by prostheses	1 (3.3)	0 (0)
	Total	2 (6.7)	6 (17.1)
Ma [5]	Total sample size	n = 10	n = 13
	Wrist pain	1 (10)	1 (7.7)
	Elbow pain	1 (10)	3 (23.1)
	Muscle weakness	1 (10)	1 (7.7)
	No healing	0 (0)	1 (7.7)
	Total	3 (30)	6 (46.2)
Ruan [9]	Total sample size	14	8
	Heterotopic ossification	3 (21.4)	0 (0)
	Nonunion and migration of fractured Fragment	0 (0)	4 (50)
	K wire loosening	0 (0)	2 (25)
	Total	3 (21.4)	6 (75)

PR group: PR: prosthesis replacement, the patients were treated by prosthesis replacement in this group; ORIF group: ORIF: open reduction and internal fixation, the patients were treated by open reduction and internal fixation in this.

investigating the long-term outcomes and considering the other populations.

5. Conclusions

In this study, there were some evidences that radial head replacement had better elbow function and fewer adverse events than ORIF for Mason type III RHF in the short-term in Chinese population. However, these evidences are of low quality and it is unknown whether these results would apply in the longer term or more generally. Further studies with larger sample size must be done to verify the results of this study.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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