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Original Article

Open reduction and internal fixation versus resection for radial head fractures: a meta-analysis

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Abstract: Purpose: Radial head resection and open reduction and internal fixation (ORIF) are the traditional techniques for the treatment of radial head fractures (RHFs). The existing literature has not identified which is superior. We performed a meta-analysis of the current literature on excision and ORIF for RHFs to reach a relatively conclusive answer. Methods: A search was performed in PubMed, OVID, EMBASE, and Cochrane Library for articles published on RHFs. We extracted and pooled patient data using standard meta-analytic approaches. The outcomes were compared using measures of functional rating score, grip strength, range of motion, pain score, physician-rated questionnaire, and complication rates. Outcomes were pooled by random-effects if high heterogeneity was detected. Sensitivity analyses were used to test the stability of the meta-analysis results under different assumptions. Results: Four studies involving 162 patients were considered eligible for analysis. Results showed ORIF was more effective for avoiding flexion contracture and degenerative change complications. For functional outcome (The American Shoulder and Elbow Surgeons Elbow Evaluation Instrument, The Broberg and Morrey functional rating score, The classification rating, The patient-based Disabilities of the Arm, Shoulder, and Hand questionnaire), ORIF had a superior capability to resection. As for the loss of grip strength, the arc of flexion/extension of the elbow and pronation/supination of the forearm, pain relief, and radiographic proximal migration of the radius, there were no significant differences between two interventions. Conclusions: To sum up, considering all these pooled outcomes, we recommend ORIF over Resection for the treatment of RHFs.

Keywords: Open reduction and internal fixation, ORIF, radial head resection, radial head fracture, meta-analysis

Introduction

In years past, most of the debate on the treatment of radial head fractures (RHFs) has centered on the excision, open reduction and internal fixation (ORIF) or replacement of the radial head. Historically, the treatment of choice for RHFs is commonly based on classification proposed by Mason and Johnston.

Severely comminuted Type 3 or Type 4 fractures are often treated by resection of the radial head with or without prosthetic replacement [2, 6-9, 11-15]. The best mode of treatment for RHFs (Mason Type 2, Type 3 and part of Type 4) remains controversial, with conflicting evidence to support either resection or ORIF [1-10]. During the past, the treatment of choice for RHFs was radial head excision after failure of nonoperative treatment [16, 17]. Recently, it has made ORIF now increasingly popular with reported successes with the improvement of surgical techniques [7, 18-20].

ORIF is believed to be superior to radial head excision for the treatment of unstable, displaced fractures of the RHFs, both in terms of strength, the initial stability of the forearm and elbow, and the avoidance of later development of arthrosis [21-24]. Improper fixation interferes with the smooth congruity of the proximal radioulnar joint, and this limits joint motion, leads to pain, and even results in complications as like osteoarthritis of adjacent joints. Radial head resection has been an option with reports of good long term functional outcomes once [25-27]. However, delayed complications, including pain, joint instability, decreased strength, com-

Table 1. Methodological Quality of the Included Studies (Newcastle-Ottawa Scale)

Study	Selection	Comparability	Outcome
Ikeda 2005	☆☆☆☆	☆☆	☆☆☆
Lindenhovius 2007	☆☆☆☆	☆☆	☆☆
Meyer-Marcotty 2002 (Germany)	☆☆☆☆	☆☆	☆☆☆
Zarattini 2012	☆☆☆☆	☆☆	☆☆

plications (cysts, sclerosis, osteophytes, joint space narrowing) have also been reported after radial head resection [28-32].

Today ORIF becomes the preferred surgical procedures for RHFs. To our knowledge, most surgeons used to hold the opinion that excision for RHFs was more likely leading to radius migration or joint space narrowing and instability, while the clinical evidence is insufficiency. Recently, several studies directly comparing resection and ORIF for RHFs have been published. To demonstrate the phenomenon why ORIF becomes the preferred operation method for RHFs, we performed this meta-analysis to check if either of these two operations is superior to the other.

Materials and methods

Literature search

A search of published literature up to June 2015 on RHFs was performed in the PubMed, OVID, EMBASE, and Cochrane Library database using the keywords *radius, radial head fracture, internal fixation, resection, excision.* No restrictions were placed on the origin or language of the publications. Reports relating to both ORIF and resection on RHFs were included. Additionally, a manual reference check of all retrieved articles was performed to identify additional references not captured by the original search.

Inclusion and exclusion criteria

While it is clearly preferable to include randomized controlled trials in meta-analyses, the paucity of such studies precluded the use of this standard. Inclusion criteria were established a *priori* to minimize any possible selection bias. All the comparative studies were included.

Articles were excluded based on the following criteria: (1) review or meta-analysis, (2) case report, case serial, and comment, (3) animal studies, (4) studies containing previously published data, (5) studies containing participants younger than 18 years, (6) study not comparing resection and ORIF, (7) manual of surgical technique, (8) participants with subsequent surgical methods successively, (9) 3 full texts of articles that published before 20st-century cannot be acquired.

Studies were independently assessed by 2 reviewers if the screening criteria were met. If the title or the abstract was judged by either reviewer to be potentially eligible, the full article would be examined. Disagreement was resolved by group assessment.

This meta-analysis was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Newcastle-Ottawa scale was used for the assessment of the methodological quality of each study (**Table 1**). This assessment was made by the 2 reviewers who were blinded regarding the source institution, the journal, and the authors for each included publication. Any disagreement was resolved by discussion between the 2 reviewers.

Statistical analysis

Available data from the selected studies were pooled using the Review Manager software from the Cochrane Collaboration. For outcome variables with a continuous nature, a weighted mean difference (MD) was calculated with 95% confidence interval (CI). For the dichotomous variables, a weighted risk ratio (RR) with 95% CI was calculated using Review Manager Software.

For the studies where continuous variables were reported with a range, the standard deviation (SD) was calculated using the method described by Walter and Yao [33]. The heterogeneity of the studies included was calculated using I^2 statistics. This measurement describes the percentage of variation that is due to heterogeneity rather than chance, across studies [34]. We also assessed heterogeneity by means of a chi-square analysis, whereby a p-value of <0.1 was considered to be suggestive of statistical heterogeneity.

The fixed-effects model (inverse-variance model) was applied when the effects were assumed to be homogenous (P>0.1, I^2<50%),

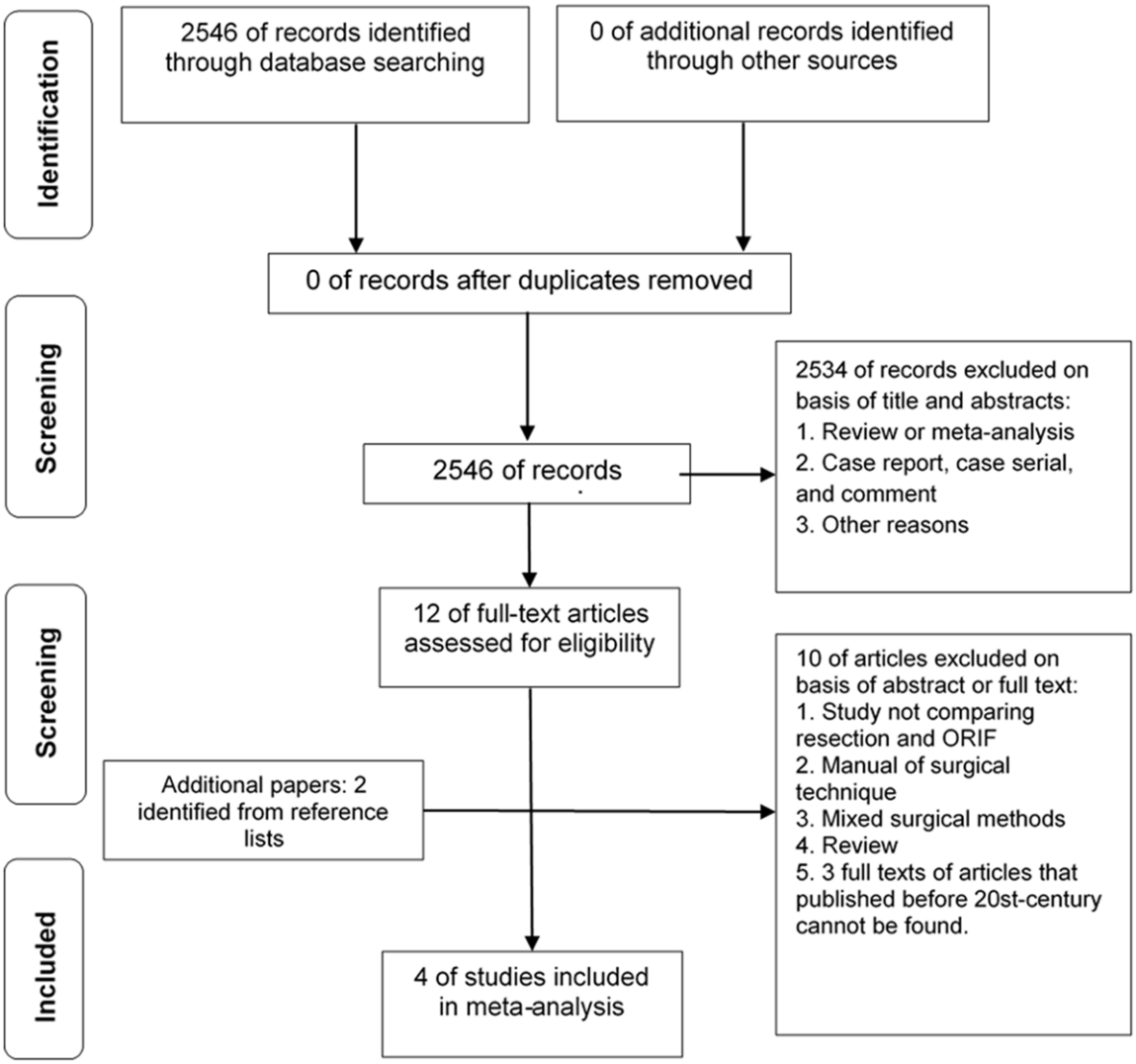

Figure 1. Flowchart of the meta-analysis.

while the random-effects model (inverse-variance model) was applied when they were heterogeneous ($P<0.1$, $I^2>50\%$). In the random-effects model, it was assumed that the studies represented a sample of the available trials. Sensitivity analysis was performed by excluding the study with obvious methodological heterogeneity.

Publication bias was assessed with funnel plots, in which the outcome (e.g. intervention effect) was plotted on the vertical axis and the covariate (e.g. the standard error of the logarithm of intervention effect) was plotted on the horizontal axis. Bias is revealed if the plots are asymmetrical about the pooled RR, whereas a plot resembling a symmetric funnel shows that no bias is present.

Forest plots were created as a graphical representation of different outcomes. The lines in the forest plot represent the confidence intervals and the dots represent the measures of effect.

Results

Study selection and characteristics

A total of 12 citations were identified from the database. A further 2 papers were obtained from the reference lists of included studies. 4 articles were included in meta-analysis. The study selection process and reasons for exclusions are summarized in **Figure 1**.

Study characteristics are listed in **Table 2**.

Table 2. Description of the studies included in the meta-analysis

Study	Methods	Participants	Interventions	Outcomes	Follow-up period
Ikeda 2005	Cohort study	28 patients Group I: 15 (11 male, 4 female) mean age 41.1 Mason type-III: 9 Mason type-IV: 6 Group II: 13 (7 male, 6 female) mean age 38.2 Mason type-III: 3 Mason type-IV: 10	Group I: radial head excision. Group II: open reduction and internal fixation.	Flexion/extension of the elbow, Flexion contracture, Pronation/supination of the forearm, Pain, The average loss of grip strength, Valgus deviation, The ASES Elbow Evaluation Instrument, The BM rating system, The classification system of BM system, Increase in carrying angle, Proximal migration of the radius, Complications and degenerative changes (cysts, sclerosis, osteophytes, joint space narrowing), et al.	Group I: 10 years (range, 3 to 18 years) Group II: 3 years (range, 2 to 4 years)
Lindenhovius 2007	Cohort study	28 patients Group I: 15 (9 male, 6 female) mean age 48 left elbow 6 (2 dominant); right elbow 9 (3 dominant) Mason type 3 fractures: 12 Mason type 2 fractures: 3 Group II: 13 (9 male, 4 female) mean age 41 left elbow 9 (2 dominant) right elbow 4 (2 dominant) Mason type 3 fractures: 8 Mason type 2 fractures: 5	Group I: radial head excision. Group II: open reduction and internal fixation.	The mean arc of flexion, Flexion/extension of the elbow, Flexion contracture, Pronation/supination of the forearm, Pain, Patient satisfaction, The ASES Elbow Evaluation Instrument, The BM rating system, The classification system of BM system, The DASH questionnaire, Returned to their pre-injury occupation, Complications, Degenerative changes (cysts, sclerosis, osteophytes, joint space narrowing), et al.	Group I: 16 years (range, 11-21 years) Group II: 18 years (range, 8 -30 years)
Meyer-Marcotty 2002 (Germany)	Cohort study	47 patients 25 Group I, 22 Group II	Group I: radial head excision. Group II: open reduction and internal fixation.	The classification criteria for Radin and Riseborough, Proximal migration of the radius, Complications, Degenerative changes (cysts, sclerosis, osteophytes, joint space narrowing), et al.	From 1993-1998.
Zarattini 2012	Retrospective study.	59 patients Group I: 24 (10 male, 14 female) mean age 41 left elbow 12; right elbow 12 Mason Type 2: 24 Group II: 35 (25 male, 10 female) mean age 40 left elbow 18; right elbow 17 Mason Type 2: 35	Group I: radial head excision. Group II: open reduction and internal fixation.	Flexion/extension of the elbow and wrist, Pronation/supination of the forearm, Pain, Maximal grip strength, Collateral ligament stability, The BM functional rating score, The classification system of BM system, The DASH questionnaire, Ulnar nerve symptoms, Proximal radio ulnar synostosis, Proximal migration of the radius, Periarticular ossification, New bone formation, Complications, Degenerative changes (cysts, sclerosis, osteophytes, joint space narrowing), et al.	Group I: 157±61.84 months Group II: 125±39.09 months.

Footnotes: ASES: American Shoulder and Elbow Surgeons; BM: Broberg and Morrey; MEPI: Mayo Elbow Performance Index. The DASH questionnaire: The patient-based Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire.

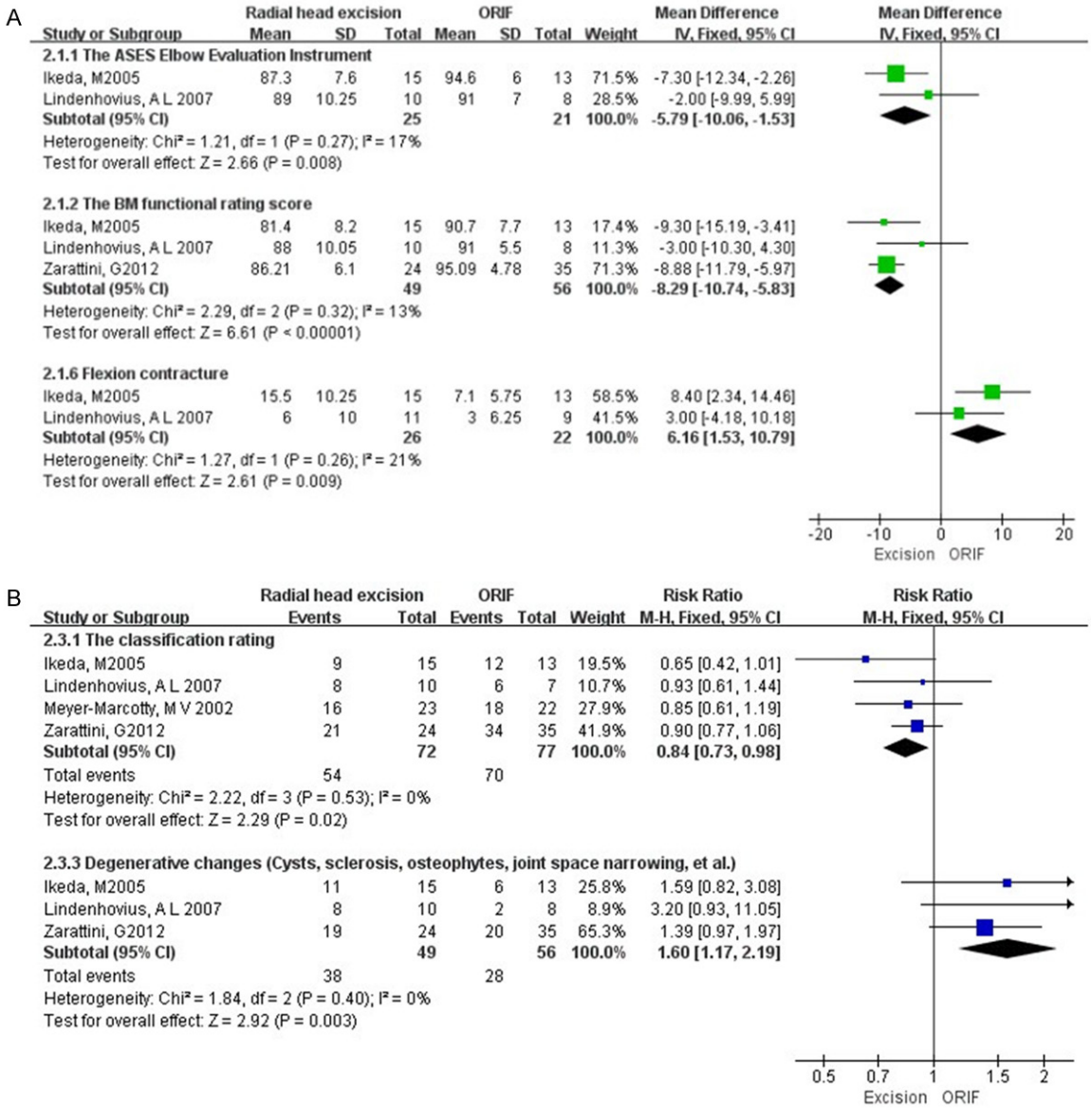

Figure 2. Forest plot comparing radial head resection and ORIF with the fixed-effect model.

The total number of patients included in all 4 studies was 162.

Not all of the studies allowed retrieval of the data for the defined outcomes. The ASES Elbow Evaluation Instrument and the BM functional rating score could be pooled, and results showed that Excision groups had lower score than ORIF groups with a statistically significant mean difference. The flexion contracture could also be pooled and Excision groups had higher degree than ORIF groups with a statistically significant mean difference. Heterogeneity of these data was low, which allowed pooling of the data (**Figure 2A**).

According to the classification rating criteria, the outcome was considered to be satisfactory if the classification rating of outcome was excellent or good and that to be unsatisfactory if the classification rating was fair or poor. All 4 studies could be pooled and it turned out that satisfactory events occurred more often in ORIF groups than in Excision groups with a statistically significant difference (**Figure 2B**). Heterogeneity was absent with an I^2 of 0%.

Of the subjective outcomes, the patient-based DASH questionnaire was used often enough to allow pooling. Result indicated that ORIF groups had higher score than Excision groups with a

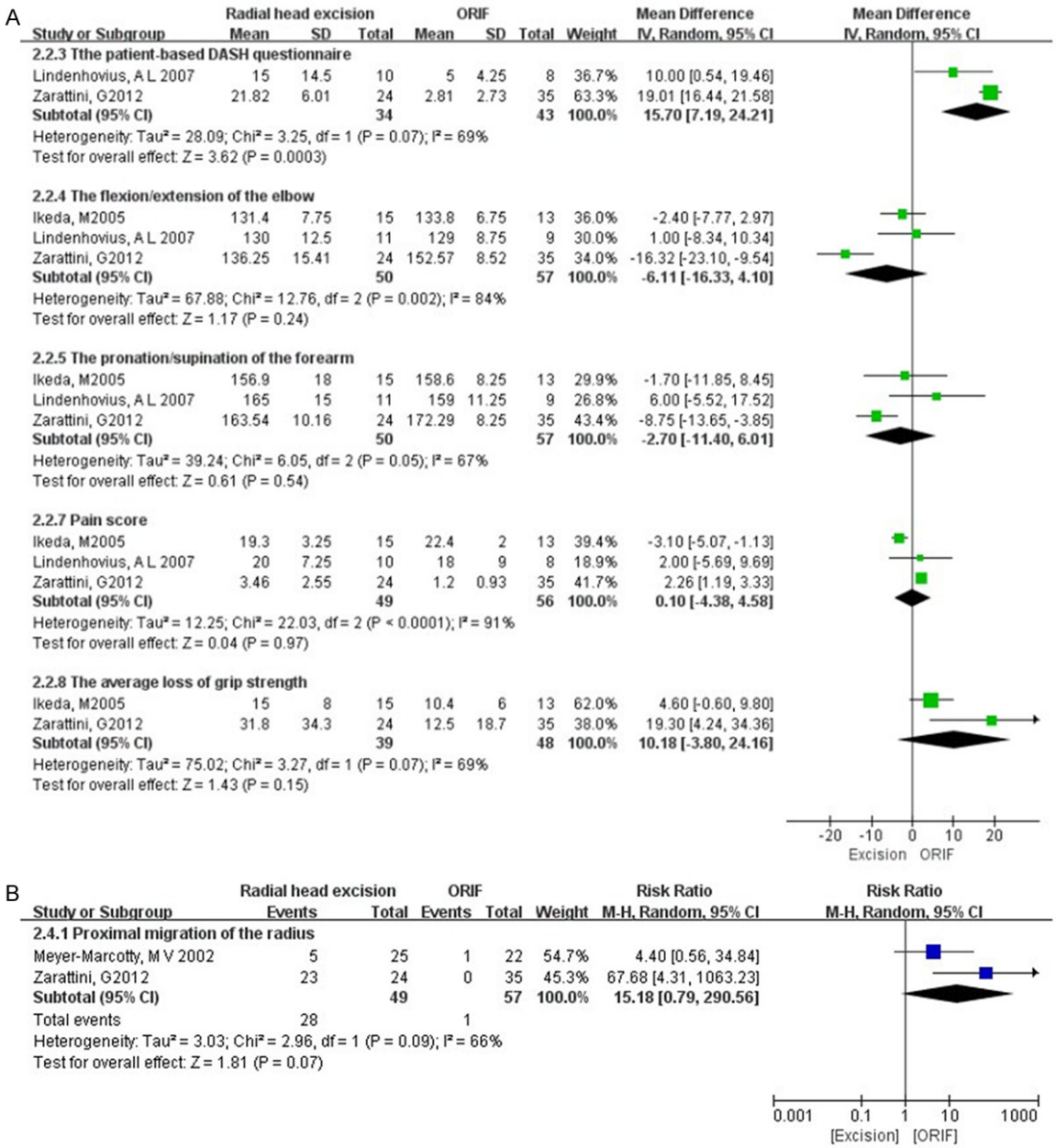

Figure 3. Forest plot comparing radial head resection and ORIF with the random-effect model.

statistically significant mean difference (**Figure 3A**). The arc of flexion/extension of the elbow and pronation/supination of the forearm in the different groups were well documented in 3 of the studies. Results showed that there were no statistically significant differences between the two interventions. As for pain score and the average loss of grip strength, both two results did not reveal any statistically significant difference. Heterogeneity of these data was high, which did not allow pooling of the data, thus the random-effects model was used (**Figure 3A**).

Of the surgical complications reported in the all included articles, radiographic proximal migration of the radius and degenerative changes (cysts, sclerosis, osteophytes, joint space narrowing) were allowed to be pooled. For proximal migration of the radius, it was always not well-defined in the same scale. Data showed that there was no statistically significant difference between the two interventions. Heterogeneity was high, and random-effects model was applied (**Figure 3B**). For degenerative changes, result showed that degenerative changes occu-

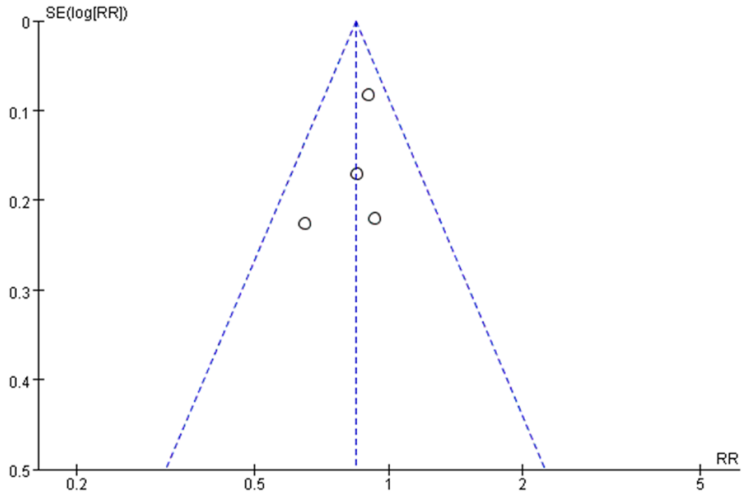

Figure 4. Funnel plot of comparison of the classification rating result.

rred more often in excision groups with a statistically significant difference of RR value; the forest plot was shown in **Figure 2B**. Heterogeneity was absent with an I^2 of 0%, and there was no evidence of publication bias.

While outcomes of the differences in re-operation rates between these two techniques as well as the frequency of implant related complications with ORIF were not able to be pooled with only the study by Guido Zarattini et al. reported 1 case of re-operation during excision group. As for early failure of fixation and non-union and elbow instability related to internal fixation or excision, the data was available with the study by Anneluuk L.C. et al. reported 1 case of non-union in ORIF group, and 1 case of elbow instability in ORIF group. Although these complications were concernedly focused on, the sample data of these outcomes was too small to be pooled.

Figure 4 shows a funnel plot for studies reporting the RRs of the comparison of the classification rating satisfactory events. The plot is symmetrical, and all studies fall within the 95% CI axis for a given standard error. And publication bias was not evident.

Discussion

As far as we know, this is a meaningful and interesting quantitative comparative meta-analysis of studies directly comparing Resection and ORIF for RHFs. Ultimately, four retrospective studies [35-37] in the literature were included in our systematic review or meta-analysis. In order to identify why ORIF becomes the preferred treatment for these RHFs, we extracted relative data as much as possible, and we pooled the outcome whenever possible.

Over the past years, people used to hold the opinion of that excision was more likely leading to migration of the radius, thus resection was performed less than ORIF. While our study discover that migration of the radius is not the most important difference between these two operations. It is functional rating score or degree of functional recovery that really makes a difference, and other complications except migration of the radius are also playing important roles.

In our study, we found the functional rating score of ORIF was higher than that of the Excision. The reason we thought was that ORIF had a better anatomical or functional reduction, a better recovery of physiological and physical function.

As for radial migration, Postacchini found that it occurred in 82% of excision cases [38]. Mikic also reported a proximal radial migration in 50% of excision series [34]. There was controversy that which operation was better avoiding this complication. In our paper, we did not find any difference between these two operations. It was maybe that there was no variance on account of that the sample studies included in the analysis was not big enough. Nonetheless, we found that radius migration tend to be occurred more often in excision cohort than that in ORIF cohort.

As a meta-analysis, there are limitations in our studies. First, almost all of the studies included in this meta-analysis are non-Randomized Controlled Trials (nRCTs), such as retrospective cohorts. And as a result of study design limitations, these studies were more likely to suffer from various kinds of bias. Publication bias is not evident, but must be interpreted with caution for the reason that the sample of included studies is not so big. Furthermore, confounding factors which were balanced by randomization

in RCTs often disturbed the observation of effect of the intervention in nRCTs. Given the potential differences in indications between these two procedures, a lingering and potentially unanswerable question based on available literature is whether differences in outcomes are due to the injury or the treatment.

Second, the outcome results are influenced by the duration of follow-up. In the studies by Ikeda et al. and Zarattini et al., there were significant differences in the duration of follow-up between patients treated with radial head resection (10 years and 157 months, respectively) relative to those treated with ORIF (3 years and 39 months, respectively). These differences likely had a significant impact on the incidence of degenerative changes and possibly strength measurements due to age-related decline between these cohorts. And this discrepancy may have had a substantial effect.

In summary, we believe that this meta-analysis, comparing resection versus ORIF for treatment of RHFs, offers useful conclusions and shows that ORIF is more effective both for avoiding flexion contracture and refrain from degenerative changes complications. Outcomes below as like migration of the radius, the arc of flexion/extension of the elbow and pronation/supination of the forearm, the loss of grip strength, and pain relief, there is no significant difference among these two interventions. Nevertheless, these uncertain outcomes' I^2 were almost so high that the reliability should be closely examined.

And for the fatal functional score (The ASES Elbow Evaluation Instrument, The BM functional rating score, The classification rating result, The DASH questionnaire), ORIF all had a superior capability for functional rehabilitation of fractures to resection. Considering all these outcomes, we strongly recommend ORIF over Resection for the treatment of controversial RHFs.

Disclosure of conflict of interest

None.

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