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Replacement or repair of terrible triad of the elbow

A systematic review and meta-analysis

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Abstract

Background: Surgical treatment for terrible triad injuries remains a challenging clinical problem, and controversy exists of whether it is better to repair or replace the radial head. The objective of this systematic review was to evaluate the clinical outcomes of repair and arthroplasty replacement of the radial head in patients with terrible triad injury.

Methods: Medline, Cochrane Library, EMBASE, and Google Scholar were searched up to July 30, 2018 to identify the relevant studies, which included patients who had received treatments of the terrible triad of the elbow and also had reported with the quantitative outcomes. Outcomes of interest were functional outcomes.

Results: Four studies with a total of 115 patients were included in the systematic review. Most patients were type II or III radial head fractures based on the Mason classification systems. Fifty-one patients received radial head repair surgery and 64 underwent replacement. Two studies had indicated that patients in the replacement group were significantly associated with better treatment outcome assessed by DASH (Disabilities of the Arm, Shoulder and Hand) and MEPS (Mayo Elbow Performance Score) scores. The meta-analysis indicated that patients with the arthroplasty replacement were associated with significantly better ROM outcomes in flexion, extension, pronation than those with radial head repaired. In addition, patients in the replacement group showed fewer post-surgery complications than those in the repair group.

Conclusions: Our review had indicated that patients with terrible triad injuries undergo arthroplasty replacement have better clinical outcomes and fewer post-surgery complications than those received the repair surgery. Radial head replacement might be a more effective treatment approach with good clinical outcomes for patients with a terrible triad of the elbow.

Abbreviations: CIs = confidence intervals, DASH = Disabilities of the Arm, Shoulder and Hand, IRB = institutional review board, MEPS = Mayo Elbow Performance Score, ORIF = the open reduction internal fixation repair, RCTs = randomized controlled trials, ROM = range of motion.

Keywords: arthroplasty, elbow, open reduction internal fixation, radial head fracture, repair, replacement, terrible triad

1. Introduction

Fracture dislocation of the elbow, termed terrible triad, involves three anatomic injuries: coronoid fracture, radial head fracture, and posterior elbow dislocation. The injury is characterized by elbow instability and development of arthrosis and joint stiffness.[1] Terrible triad injuries are difficult to manage and historically have poor outcomes.[2–6]

The main goal of surgery is to restore the stability of the humero-ulnar and humero-radial joints and lateral collateral ligament reconstruction, with the purpose of facilitating early postoperative elbow motion to reduce the chance of long-term joints stiffness and disability.[7,8] To achieve this goal, surgery must address all three injury components of the terrible triad.[9] To date, however, there is no consensus as to the optimal means of surgical management.[8] A number of surgical approaches have been reported for managing this injury, however, the reports differ with respect to surgical approach used, the means of fixation, and type of implant used when the joint requires replacement.[7] The current standard surgical protocols for treating terrible triad injury include fixation of the coronoid fracture, repair or replacement of the radial head, and repair of the lateral ligament complex, reserving medial collateral ligament repair and application of hinged external fixation for patients with residual instability.[5] The open reduction internal fixation repair (ORIF) and arthroplasty replacement are routinely required to adequately treat this injury.

However, surgical treatment for terrible triad injuries of the elbow remains challenging, and specifically, there is controversy of whether the radial head injury should be surgically repaired or replaced with a prosthesis. The purpose of this systematic review

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was to evaluate the functional outcomes, such as range of motion (ROM) and elbow use, of surgical repair and arthroplasty in treatment in patients with terrible triad injuries.

2. Methods

2.1. Search strategy

The study was performed in accordance with the PRISMA guidelines. Medline, Cochrane, EMBASE, and Google Scholar databases were searched up to July 30, 2018 using the following search terms: radial head fracture, terrible triad, elbow, replacement, arthroplasty, repair, open reduction internal fixation. Randomized controlled trials (RCTs), prospective studies, retrospective studies, and cohort studies were included. Included studies had to have evaluated patients with terrible triad fracture injury who had replacement of the radial head with a prosthesis or surgical repair of the radial head fracture. Studies had to have reported quantitatively outcomes of interest. Letters, comments, editorials, case report, proceeding, personal communication, and case series were excluded.

The ethical approval and informed consent were not necessary, because meta-analysis does not involve human subjects and does not require institutional review board review.

2.2. Study selection and data extraction

Studies identified by the search strategy were hand-searched and reviewed for inclusion and data was extracted by two independent reviewers. Where there was uncertainty regarding study eligibility, a third reviewer was consulted. The following information/data were extracted from studies that met the inclusion criteria: the name of the first author, year of publication, study design, number of participants in each group, participants' age and gender, Mason type, and the major outcomes.

2.3. Quality assessment

The quality of the included studies was assessed by using the modified 18-item Delphi checklist.[10]

2.4. Outcome measures

The primary outcome were functional outcomes measured by the range of motion (ROM) and Mayo Elbow Performance Score (MEPS).

2.5. Statistical analysis

Difference in means with 95% confidence intervals (CIs) were calculated for continuous outcomes between patients in the repair and replacement groups for each individual study and for all the studies combined. A χ^2-based test of homogeneity was performed and the inconsistency index (I^2) and Q statistics were determined. Heterogeneity determined using the I^2 statistic was defined as follows: 0 to 24% = no heterogeneity; 25 to 49% = moderate heterogeneity; 50 to 74% = large heterogeneity; and 75 to 100% = extreme heterogeneity. Because the number of studies included in the meta-analysis was small, heterogeneity tests had low statistical power.[11] When tests for heterogeneity are underpowered, random-effects models are routinely used.[12] In addition, The National Research Council report recommends the use of random-effects approaches for meta-analysis and the exploration of sources of variation in study results.[13] Pooled effects were calculated, and a 2-sided P value $< .05$ was considered to indicate statistical significance. All analyses were performed using Comprehensive Meta-Analysis statistical software, version 2.0 (Biostat, Englewood, NJ, USA).

3. Results

3.1. Search results

A total of 240 studies were identified in the initial research (Fig. 1). Of those, 213 were excluded for not being relevant by reviewing titles and abstracts. Twenty-seven studies underwent full-text review and 23 were excluded for not comparing replacement with repair of the radial head, being one arm studies or no full text. Finally, 4 studies were included in the systematic review.

3.2. Study characteristics

The main demographics of these 4 studies included in the systematic review were summarized in Table 1.[14–17] One study was an RCT[14] and the other three were retrospective in design.[15–17] The total number of patients in the studies was 115 and divided to the radial head repair group ($n = 51$) and the radial head replacement group ($n = 64$). In the repair group, the intervention was involving ORIF surgery; while in the radial head replacement group, the different prostheses were used and made of metal or silicon. The Mason classification varied across studies with most patients with type II or III. The mean age among the studies ranged from 35 to 46 years. Male patients were a majority (>50%) in most studies. The length of follow up ranged from 24 to 40.6 months.

3.3. Summary of functional outcomes

The results of the functional outcome assessed by Disabilities of the Arm, Shoulder and Hand (DASH) score, MEPS score, and ROM by the comparison of the radial head repair group with the radial head replacement group was shown in Table 2. Yan et al in 2015 found that MEPS, flexion-extension arc, and pronation-supination arc were significantly better in the replacement group compared to the repair one ($P < .05$).[14] The studies of Watters et al (2014) and Leigh et al (2012) found that there was no significant difference between the variables in ROM and elbow scores by the companion of these two groups.[15,16] However, the radial head replacement group scored significantly higher values on the DASH assessment reported in the study by Leigh et al. Jeong et al (2010) also suggested that both radial head repair group and radial head replacement group provided the same level of satisfactory clinical outcomes.[17]

3.4. Meta-analysis

All studies were included in the meta-analysis and evaluated the difference in the variables such as ROM (flexion and extension, etc) and MEPS by either ORIF repair or replacement surgery (Table 3). No heterogeneity in the flexion data of ROM was observed among the 4 studies for flexion (Q statistic = 3.386, I^2 = 11.40%) and moderate heterogeneity was showed for extension (Q statistic = 4.142, I^2 = 27.57%) (Table 3). The pooled analysis found that patients had significantly better flexion results in the replacement group than those in the repair group (pooled difference in means = −2.97, 95% CI: −5.88 to −0.06, $P = .045$).

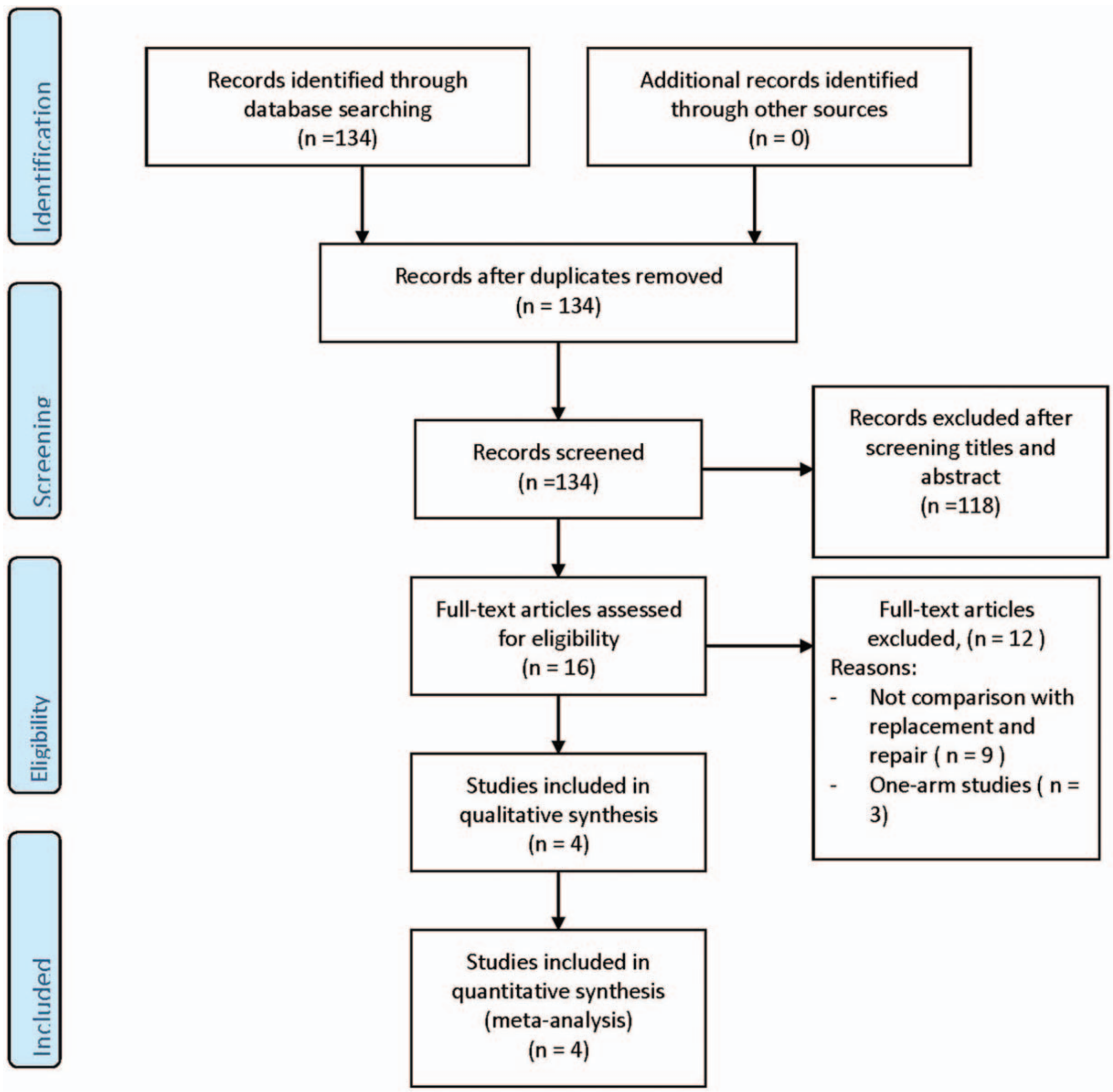

Figure 1. PRISMA 2009 flow diagram of study selection.

The replacement group also demonstrated greater extension outcomes (pooled difference in means = 4.49, 95% CI: 1.64–7.35, P = .002) compared with the repair group.

Three studies (Yan et al (2015), Leigh et al (2012), and Jeong et al (2010)) with pronation and supination from ROM data were included in the meta-analysis. No heterogeneity in pronation and supination data were observed among the three studies (both I^2 = 0%). The results of the meta-analysis revealed that patients in the replacement group had significantly better pronation results than those in the repair group (pooled

Table 1

Baseline demographics of the selected studies.

First author (year)	Study design	Number of patients	Intervention	Mason (%) (I/II/III/IV)	Age	Male (%)	Follow-up (months)
Yan (2015)	RCT	19	Repair (ORIF)	0/0/100%/0	35.51	37%	36
		20	Replacement (metal monopolar)		36.54	55%	
Watters (2014)	Retrospective	9	Repair (ORIF)	0/56%/44%/0	48	54%	24
		30	Replacement (modular EVOLVE)	0/60%/40%/0			
Leigh (2012)	Retrospective	13	Repair	13%/37%/50%/0	42.2	46%	40.6
		11	Replacement (Avante or EVOLVE)		45.5	64%	
Jeong (2010)	Retrospective	10	Repair (ORIF)	20%/70%/10%/0	43.8	54%	25
		3	Replacement (1: silicon, 2: metal)	0/0/100%/0			

RCT = randomized controlled trial, ORIF = open reduction internal fixation.

Table 2

Summary of functional outcomes in patients treated with repair or replacement.

First author (year)	DASH	MEPS	Range of motion (degree) (ORIF repair vs. arthroplasty replacement) Flexion (°)	Extension (°)	Flexion/extension arc (°)	Pronation (°)	Supination (°)	Pronation/supination arc (°)
Yan (2015)	NA	78 vs. 86*	114 vs. 117	22 vs. 17	92 vs. 101*	57 vs. 63*	50 vs. 51	103 vs. 114*
Watters (2014)	15.7 vs. 16.1	NA	130 vs. 137	24 vs. 20	106 vs. 118	NA	NA	NA
Leigh (2012)	9.16 vs. 10.83*	NA	135 vs. 135	15 vs. 5	115 vs. 128	70 vs. 80	75 vs. 75	120 vs. 150
Jeong (2010)	NA	95 vs. 95	137 vs. 138	8 vs. 7	123 vs. 130	68 vs. 72	65 vs. 70	133 vs. 142

DASH = Disabilities of the Arm, Shoulder and Hand, MEPS = Mayo Elbow Performance Score, NA = not available, ORIF = open reduction internal fixation.

* $P < .05$.

difference in means = −6.07, 95% CI: −11.52 to −0.63, $P = .029$). However, there was no significant difference in supination between the two groups (pooled difference in means = −1.61, 95% CI: −6.07 to 2.85, $P = .479$).

Results for flexion/extension arc of patients were provided by all four studies yet the results of pronation-supination motion were only shown in three (Yan et al (2015), Leigh et al (2012), and Jeong et al (2010)). No heterogeneity was observed among these studies for these variables (both $I^2 = 0\%$). The pooled analysis indicated that in the flexion–extension arc (pooled difference in means = −8.52, 95% CI: −13.84 to −3.20, $P = .002$, Fig. 2A) and pronation-supination motion arc (pooled difference in means = −13.03, 95% CI: –22.24 to −3.82, $P = .006$, Fig. 2B) variables, patients in the replacement group have significantly greater outcomes than those in the repair group.

Only two studies (Yan et al (2015) and Jeong et al (2010)) had provided MEPS results and were included in the meta-analysis. A moderate heterogeneity between the two groups was observed (Q statistic = 1.807, $I^2 = 44.67\%$). The results of meta-analysis showed there was no significant difference in MEPS between the two groups (pooled difference in means = −4.54, 95% CI: −12.18 to 3.11, $P = .245$, Table 3).

3.5. Summary of complications

Table 4 shows the summary of complications experienced in patients in both groups among four studies. In Yan et al study, patients in the repair group had more post-surgery complications, such as stiffness, heterotopic ossification, internal fixation failure, and required secondary coronoid fragment displacement by comparing with those in the replacement group. Watters et al also indicated that the number of patients with post-surgery complications included elbow instability, hardware failure, and reoperation and coronoid nonunion/malunion were greater in the repair group than in the replacement group. However, the overstuffing of prosthesis was only showed in patients with the replacement surgery in both studies. Heterotopic ossification reported by Jang et al happened in patients with the repair surgery, yet ulnar neuropathy was observed in patients with the replacement surgery. Overall, patients in the replacement group showed fewer post-surgery complications than those in the repair group.

3.6. Quality assessment

A modified 18-item Delphi technique was used to evaluate the quality of the involved articles in systematic review (Table 5). We derived an 18-item checklist as the full score. The score ranging from 9 to 15 were classified as good quality. Four studies we included in this review had score ranging from 11 to 15, which were considered as good quality.

4. Discussion

Surgical treatment for terrible triad injuries remains a challenging clinical problem, and controversy exists of whether it is better to repair or replace the radial head with a prosthesis. The aim of this study was to evaluate whether repair or replacement of the radial head is the favorable treatment for radial head fracture in patients with terrible triad. Four studies with a total of 115 patients were included in the systematic review. Most patients were type II or III radial head fractures based on the Mason classification systems. Fifty-one patients received radial head repair surgery and 64 underwent replacement. Two studies had indicated that patients in the replacement group were significantly associated with better treatment outcomes assessed by DASH and MEPS scores. The meta-analysis indicated that patients with the arthroplasty replacement were associated with significantly better ROM outcomes in flexion, extension, pronation than those with radial head repaired. In addition, patients in the replacement group

Table 3

Results of meta-analysis for range of motion and MEPS outcomes.

	Heterogeneity Number of studies	*Q* statistics	I^2	Pooled results Difference in means (95% CI)	*P*-value
Range of motion					
Flexion	4	3.386	11.40%	−2.97 (−5.88, −0.06)	0.045
Extension	4	4.142	27.57%	4.49 (1.64, 7.35)	0.002
Pronation	3	0.43	0.00%	−6.07 (−11.52, −0.63)	0.029
Supination	3	0.182	0.00%	−1.61 (−6.07, 2.85)	0.479
MEPS	2	1.807	44.67%	−4.54 (−12.18, 3.11)	0.245

CI = confidence interval, MEPS = Mayo Elbow Performance Score.

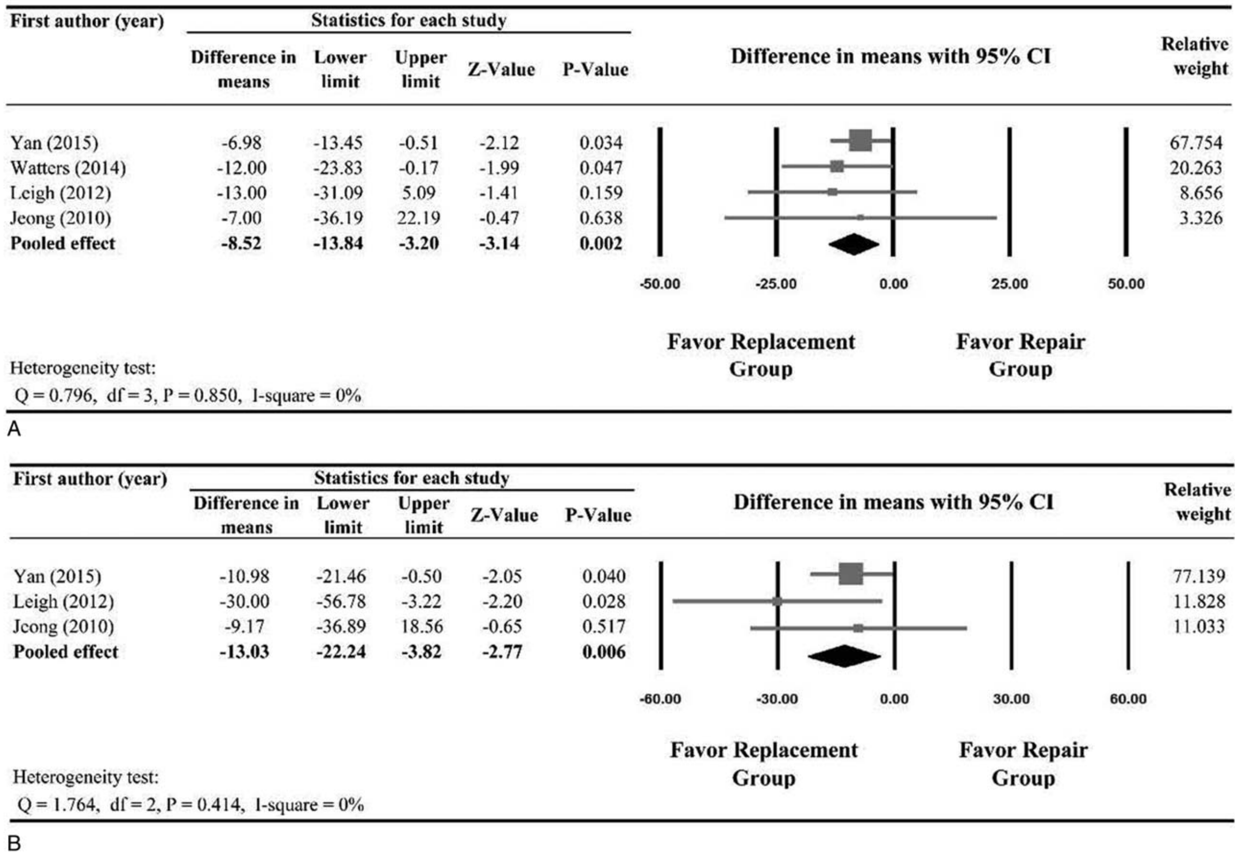

Figure 2. Results of meta-analysis for (A) flexion/extension arc and (B) pronation-supination motion arc.

showed fewer post-surgery complications than those in the repair group. To our knowledge, this was the first meta-analysis performed to compare radial head replacement with repair of the radial triad in the treatment of terrible triad injury.

Over the years, the type of implant material for radial head arthroplasty has expanded and includes acrylic, silicone, cobalt-chromium, titanium, and pyrocarbon.[18] Although one of our studies employed silicone prostheses, the use of silicone implants has decreased due to their inability to reconstitute normal biomechanics, resulting in suboptimal wear characteristics, particulate debris, elbow instability, and implant failure.[19] However, the type of implant used is probably less important than surgical technique and the surgeon's experience, which may help to avoid oversizing and overstuffing the radial head prosthesis.[14,18] Oversizing and overstuffing the radial head implant can result in reoperation.[14]

Complications following repair or arthroplasty are relatively common.[7] For radial head arthroplasty, development of posttraumatic arthritis and capitellar wear are concerns, with estimates ranging from 19% at short-term follow-up to 74% at long-term follow up.[18] A systematic review performed by Chen et al (2014) summarized the evidence regarding complications following surgery (either repair or replacement) for terrible triad injury.[7] The review included 16 studies with 312 patients. Chen et al found that about a third of the patients (range across studies from 0% to 54%) required reoperation due to complications and that most of the complications were related to hardware fixation problems, joint stiffness, joint instability, and ulnar neuropathy.

Table 4

Summary of complications in patients treated with repair or replacement.

	Complications % (ORIF repair vs. arthroplasty replacement)											
	Total	Elbow instability	Stiffness	Secondary coronoid fragment displaced	Heterotopic ossification	Overstuffing of prosthesis	Internal fixation failure	Hardware failure	Arthrosis	Reoperation	Coronoid nonunion/ malunion	Ulnar neuropathy
Yan (2015)	47.4 vs. 20	–	21.1 vs. 5	10.5 vs. 5	10.5 vs. 5	0 vs. 5	5.3 vs. 0	–	–	–	–	–
Watters (2014)	–	33 vs. 0	–	–	–	NA vs. 10	–	22 vs. NA	0 vs. 37	44.4 vs. 23.3	44.4 vs. 6.7	–
Leigh (2012)	–	–	–	–	–	–	–	–	–	29%	–	–
Jeong (2010)	–	–	–	–	20 vs. NA	–	–	–	–	–	–	NA vs. 33.3

NA = not available, ORIF = open reduction internal fixation.

Table 5

Quality assessment of included studies with modified 18-item Delphi checklist.

Checklist	Yan (2015)	Watters (2014)	Leigh (2012)	Jeong (2010)
Is the hypothesis/aim/objective of the study clearly stated in the abstract, introduction, or methods section?	Y	Y	Y	Y
Are the characteristics of the participants included in the study described?	Y	Y	Y	Y
Were the cases collected in more than one centre?	N	Y	N	N
Are the eligibility criteria (inclusion and exclusion criteria) to entry the study explicit and appropriate?	Y	Y	Y	Y
Were participants recruited consecutively?	N	N	Y	Y
Did participants enter the study at a similar point in the disease?	Y	Y	Y	Y
Was the intervention clearly described in the study?	Y	Y	Y	Y
Were additional interventions (co-interventions) clearly reported in the study?	N	N	N	N
Are the outcome measures clearly defined in the introduction or methods section?	N	Y	Y	Y
Were relevant outcomes appropriately measured with objective and/or subjective methods?	Y	Y	Y	Y
Were outcomes measured before and after intervention?	N	N	N	N
Were the statistical tests used to assess the relevant outcomes appropriate?	Y	Y	Y	NA
Was the length of follow-up reported?	Y	Y	Y	Y
Was the loss to follow-up reported?	N	Y	Y	Y
Does the study provide estimates of the random variability in the data analysis of relevant outcomes?	Y	Y	Y	Y
Are adverse events reported?	Y	Y	Y	Y
Are the conclusions of the study supported by results?	Y	Y	Y	Y
Are both competing interest and source of support for the study reported?	N	N	Y	Y
Score	11	14	15	14

N=high risk of bias, NA=unclear risk of bias, Y=low risk of bias.

The most common complications that did not require reoperation were arthrosis (11.2%) and heterotopic ossification (12.5%). Across the studies, they found that functional outcomes were generally satisfactory with a mean MEPS ranging from 78 to 95. Chen et al did not evaluate whether a difference existed in complication rate between repair or arthroplasty surgery.

The study has several limitations that should be considered. Only four studies were included in the analysis and the overall patient population was small. In addition, only one study was an RCT. Most patients had radial head fracture of Mason type II or III; hence, it is unclear if the findings can translate to other Mason type radial head fractures. Studies that compare repair and replacement surgical strategies for other Mason type radial fractures are warranted. Across the studies the types of prostheses used differed, which may have impacted outcomes.

In summary, patients with terrible triad injuries undergoing arthroplasty replacement have better clinical outcomes and fewer post-surgery complications than those received with the repair surgery. Our review suggests that radial head replacement might be a more effective treatment approach with good clinical outcomes for patients with a terrible triad of the elbow. However, larger prospective trials would still be required to better describe the optimum surgical algorithm for this difficult injury.

Author contributions

Conceptualization: Hongwei Chen, Yinchu Shao, Shaobo Li.
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Writing – review & editing: Hongwei Chen, Yinchu Shao, Shaobo Li.

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