Olecranon osteotomy *vs*. triceps-sparing for open reduction and internal fixation in treatment of distal humerus intercondylar fracture: a systematic review and meta-analysis

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Abstract

Background: The open reduction and internal fixation (ORIF) was a standard treatment approach for fracture at distal humerus intercondylar, whereas the optimal way before ORIF remains inconclusive. We, therefore, performed a systematic review and meta-analysis to assess the efficacy and safety of olecranon osteotomy *vs*. triceps-sparing approach for patients with distal humerus intercondylar fracture.

Methods: The electronic searches were systematically performed in PubMed, EmBase, Cochrane library, and Chinese National Knowledge Infrastructure from initial inception till December 2019. The primary endpoint was the incidence of excellent/good elbow function, and the secondary endpoints included Mayo elbow performance score, duration of operation, blood loss, and complications.

Results: Nine studies involving a total of 637 patients were selected for meta-analysis. There were no significant differences between olecranon osteotomy and triceps-sparing approach for the incidence of excellent/good elbow function (odds ratio [OR]: 1.37; 95% confidence interval [CI]: 0.69–2.75; $P = 0.371$), Mayo elbow performance score (weight mean difference [WMD]: 0.17; 95% CI: −2.56 to 2.89; $P = 0.904$), duration of operation (WMD: 4.04; 95% CI: −28.60 to 36.69; $P = 0.808$), blood loss (WMD: 33.61; 95% CI: −18.35 to 85.58; $P = 0.205$), and complications (OR: 1.93; 95% CI: 0.49–7.60; $P = 0.349$). Sensitivity analyses found olecranon osteotomy might be associated with higher incidence of excellent/good elbow function, longer duration of operation, greater blood loss, and higher incidence of complications as compared with triceps-sparing approach.

Conclusions: This study found olecranon osteotomy did not yield additional benefit on the incidence of excellent/good elbow function, while the duration of operation, blood loss, and complications in patients treated with olecranon osteotomy might be inferior than triceps-sparing approach.

Keywords: Olecranon osteotomy; Triceps-sparing approach; Distal humerus intercondylar fracture; Systematic review; Meta-analysis

Introduction

Distal humerus intercondylar fracture (DHIF) is defined as intra-articular and comminuted fractures, which is always associated with soft tissue injury.[1] The complexity of anatomy causes additional treatment challenges for DHIF. Currently, the surgical operation with parallel or orthogonal plate fixation of the medial and lateral columns is widely used for patients with DHIF.[2,3] However, the drawbacks for the soft tissue dissection, subsequent scarring and non-union remain challenges for DHIF.

Nowadays, olecranon osteotomy was considered as a gold standard technique before the open reduction and internal fixation because it could display articular discrepancies. Para-tricipital incision applied for comminuted fractures could anatomically reduce and fix DHIF.[4] The locking compression plate and distal humerus plate system were associated with high quality reconstructions and good stability, enabling early mobilization for patients with DHIF.[5] However, several complications were still detected for DHIF although the advances in implant, surgical, and fixation techniques.[6] Whether the treatment effectiveness of olecranon osteotomy is superior than triceps-sparing approach for DHIF patients remains controversial. Therefore, this meta-analysis was conducted to compare the

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efficacy and safety of olecranon osteotomy *vs.* triceps-sparing approach for patients with DHIF.

Methods

Data sources, search strategy, and selection criteria

The current systematic review and meta-analysis was carried out following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Statement.[7] Comparison with the efficacy and safety of olecranon osteotomy and triceps-sparing approach for DHIF patients was eligible in this study, and no restriction was placed on publication language. The PubMed, EmBase, Cochrane library, and Chinese National Knowledge Infrastructure were searched from inception to December 2019, and the following core terms were used: "distal humerus intercondylar fracture" and ("olecranon osteotomy" or surgical). The detail search strategy in EmBase was presented in Supplementary Material, http://links.lww.com/CM9/A484. The references of retrieved studies were manually searched to identify any new eligible study.

The literature search and study selection were performed by two authors following a standardized flowchart, and conflicts between authors were resolved by group discussion until a consensus was reached. Inclusion criteria were as follows: (1) patients: DHIF; (2) intervention: olecranon osteotomy; (3) control: triceps-sparing approach; (4) outcome: excellent/good elbow function, Mayo elbow performance score, duration of operation, blood loss, and complications; and (5) study design: randomized controlled trials (RCTs), prospective or retrospective observational studies.

Data collection and quality assessment

The abstracted data included: first author's name, publication year, country, study design, sample size, mean age, percentage of males, intervention, diagnosis criteria and fracture type, and reported outcomes. Study quality for RCTs was assessed by the JADAD scale[8] and Cochrane criteria guidelines. The quality of observational studies was assessed by the Newcastle-Ottawa Scale (NOS), which was based on selection (four items), comparability (one item), and outcome (three items).[9] The scoring system of JADAD scale ranged from 0 to 5, and the scoring system of NOS ranged from 0 to 9. Two authors independently conducted the data abstraction and quality assessment, and any disagreement was settled by an additional author reading the full-text of included studies.

Statistical analysis

The efficacy and safety of olecranon osteotomy *vs.* triceps-sparing approach for DHIF patients were assigned as categorical and continuous data, then the pooled odds ratio (OR) and weighted mean difference (WMD) with 95% confidence interval (CI) were calculated using the random-effects model, which could consider the underlying varies among included studies.[10,11] The I^2 test and Q statistic were applied to assess the heterogeneity across included studies, and significant heterogeneity was regarded as $I^2 > 50.0\%$ or $P < 0.10$.[12,13] Sensitivity analysis was conducted to assess the robustness of pooled conclusion by sequentially excluding single study.[14] The incidence of excellent/good elbow function between olecranon osteotomy and triceps-sparing approach was also stratified by country, study design, sample size, age, and percentage of males, and the interaction P test was also conducted between sub-groups.[15] Moreover, sub-group analyses for Mayo elbow performance score, duration of operation, blood loss, and complications were also conducted according to study design. After this, the publication bias for excellent/good elbow function was assessed using the funnel plot, Egger's, and Begg's tests.[16,17] The P value for pooled results was two-sided, and $P < 0.05$ was considered as statistically significant. STATA software (version 10.0; Stata Corporation, College Station, TX, USA) was applied for conducting all of statistical analyses in this meta-analysis.

Results

Literature search

A total of 246 articles were identified from the PubMed, EmBase, Cochrane library, and Chinese National Knowledge Infrastructure, and three studies were identified from manual searches. Two hundred and twenty-six studies were excluded because of duplicate and irrelevant articles. The remaining 23 studies were retrieved for further full-text evaluations, and 14 articles were excluded because of no appropriate control ($n = 8$), no sufficient data ($n = 5$), and review ($n = 1$). After this, a total of nine studies were retrieved for final quantitative analysis.[18-26] The details of study selection process were arranged in Figure 1.

Study characteristics

The characteristics of studies and included patients were summarized in Table 1. Four studies were designed as RCTs, and the remaining five studies were designed as observational studies. Seven studies were conducted in China, one study was conducted in Finland, and the remaining one study was conducted in Pakistan. The nine included studies involved a total of 637 patients, and 21 to 150 patients were included in each study. The JADAD score of RCTs ranged from 1 to 3, and the NOS score of observational studies ranged from 5 to 6. Moreover, the details of quality assessment in individual study were shown in Supplementary Table S1 and S2, http://links.lww.com/CM9/A484.

Excellent/good elbow function

Data for the effect of olecranon osteotomy *vs.* triceps-sparing approach on the incidence of excellent/good elbow function were reported in eight studies. No significant difference between olecranon osteotomy and triceps-sparing approach for the incidence of excellent/good elbow function was detected (OR: 1.37; 95% CI: 0.69–2.75; $P = 0.371$ [Figure 2]. Moreover, significant heterogeneity was detected across included studies ($I^2 = 56.5\%$; $P = 0.024$). Sensitivity analysis found the incidence of excellent/good elbow function might increase in patients treated with olecranon osteotomy after excluding the study conducted by Liu *et al*[24] (OR: 1.81; 95% CI: 1.04–3.15; $P = 0.035$; $I^2 = 23.6\%$; $P = 0.249$). Moreover,

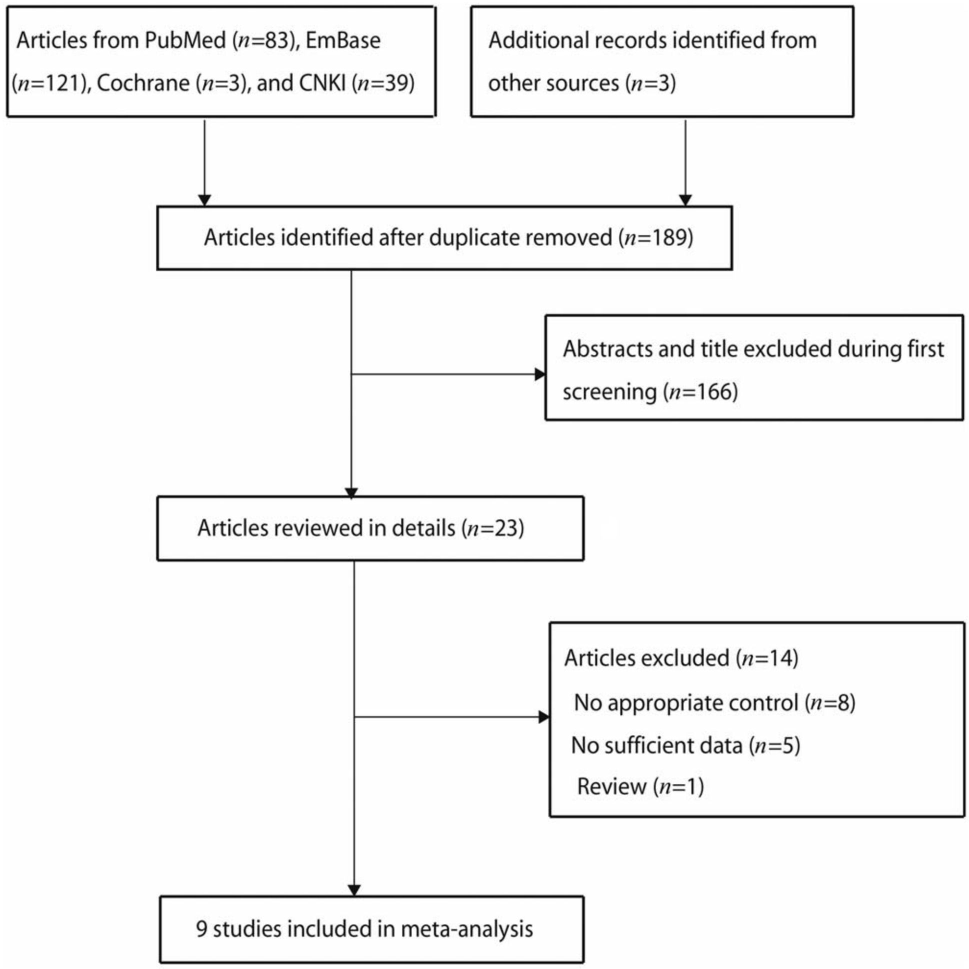

Figure 1: The PRISMA flowchart for the study selection process. PRISMA: Preferred reporting items for systematic reviews and meta-analysis.

Table 1: The characteristics of included studies and patients in the meta-analysis.

Study	Country	Study design	Sample size (*n*)	Mean age (years)	Percent of male (%)	Intervention	Criteria	Type	Study quality
Pajarinen, 2002[18]	Finland	Retrospective	21	44.4	38.1	Olecranon osteotomy; triceps-splitting	AO/ASIF	C1: 6; C2: 12; C3: 3	5
Liu, 2009[19]	China	Prospective	38	43.0	55.3	Olecranon osteotomy; triceps-splitting	AO	C1: 9; C2: 17; C3: 12	6
Chen, 2011[20]	China	Retrospective	67	44.5	44.8	Olecranon osteotomy; triceps-splitting	AO	C1: 10; C2: 28; C3: 29	6
Zhang, 2014[21]	China	Retrospective	67	69.3	37.3	Olecranon osteotomy; triceps-splitting	AO	C1: 16; C2: 25; C3: 26	5
Fu, 2015[22]	China	Randomized controlled trial	64	30.2	65.6	Olecranon osteotomy; triceps-splitting	AO	C1: 25; C2: 32; C3: 7	2*
Khalid, 2015[23]	Pakistan	Randomized controlled trial	150	49.0	62.7	Olecranon osteotomy; triceps-splitting	NA	NA	3*
Liu, 2017[24]	China	Randomized controlled trial	108	42.4	63.0	Olecranon osteotomy; triceps-splitting	AO	C1: 25; C2: 68; C3: 15	2*
Wang, 2017[25]	China	Randomized controlled trial	80	40.3	60.0	Olecranon osteotomy; triceps-splitting	AO	C1: 21; C2: 35; C3: 24	1*
Tan, 2018[26]	China	Retrospective	42	41.5	73.8	Olecranon osteotomy; triceps-splitting	NA	NA	5

*Assessed using the JADAD scale, the remaining studies were assessed using the Newcastle-Ottawa Scale. AO: Arbeitsgemeinschaft für Osteosynthesefragen; ASIF: The Association for the Study of Internal Fixation; NA: Not available.

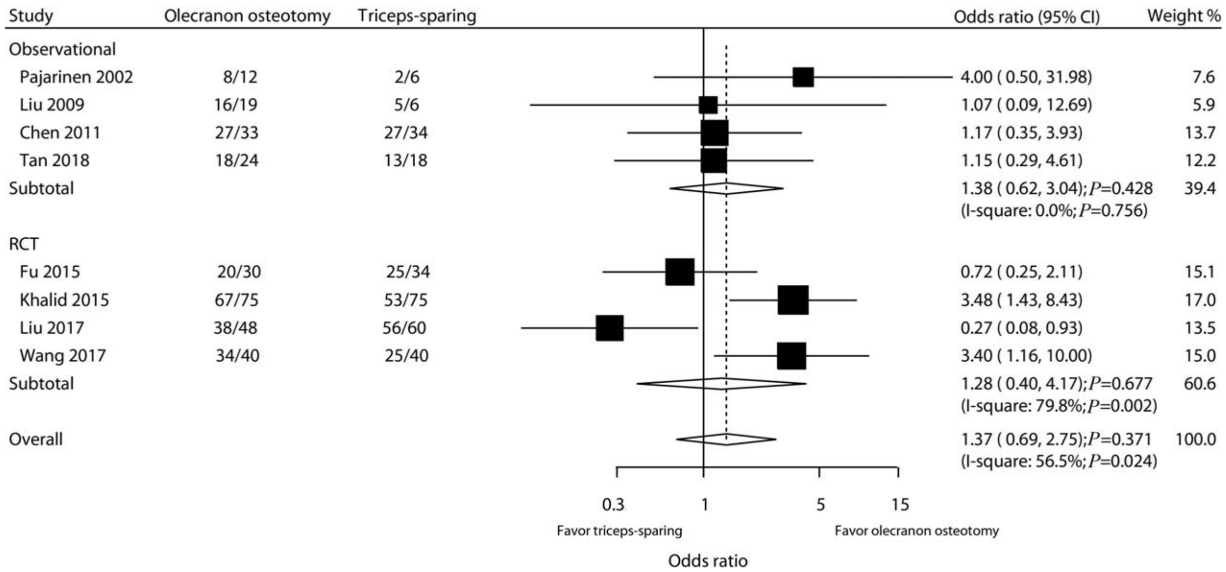

Figure 2: Effect of olecranon osteotomy *vs.* triceps-sparing approach on the incidence of excellent/good elbow function. CI: Confidence interval; RCT: Randomized controlled trial.

Table 2: Sub-group analyses for excellent/good elbow function.

Factors	Sub-group	OR (95% CI)	*P* value	Heterogeneity (%)	*P* value for heterogeneity	*P* value between sub-groups
Country	China	1.00 (0.48–2.11)	0.995	48.5	0.084	0.012
	Other	3.55 (1.57–8.02)	0.002	0	0.903	
Sample size (n)	≥100	1.01 (0.08–12.27)	0.995	90.8	0.001	1.000
	<100	1.47 (0.84–2.59)	0.180	4.4	0.389	
Age	≥42.0 years	1.33 (0.44–3.98)	0.612	66.6	0.018	1.000
	<42.0 years	1.44 (0.54–3.79)	0.465	51.6	0.127	
Percentage of males	≥60%	1.27 (0.48–3.33)	0.627	73.3	0.005	0.961
	<60%	1.50 (0.57–3.94)	0.410	0	0.579	

CI: Confidence interval; OR: Odds ratio.

sub-group analyses found olecranon osteotomy was associated with high incidence of excellent/good elbow function when pooled studies were conducted in Finland or Pakistan [Table 2].

Mayo elbow performance score

Data for the effect of olecranon osteotomy *vs.* triceps-sparing approach on Mayo elbow performance score were reported in four studies. There was no significant difference between olecranon osteotomy and triceps-sparing approach for Mayo elbow performance score (WMD: 0.17; 95% CI: −2.56–2.89; $P = 0.904$) [Figure 3], and potentially significant heterogeneity was observed ($I^2 = 59.0\%$; $P = 0.063$). This conclusion was robust and not affected by any specific study. Sub-group analyses indicated no significant difference between olecranon osteotomy and triceps-sparing approach for Mayo elbow performance score, irrespective pooled RCTs or observational studies [Figure 3].

Duration of operation

Data for the effect of olecranon osteotomy *vs.* triceps-sparing approach on duration of operation were reported in four studies. We noted no significant difference between groups for the duration of operation (WMD: 4.04; 95% CI: −28.60–36.69; $P = 0.808$) [Figure 4], and substantial heterogeneity among included studies was observed ($I^2 = 98.1\%$; $P < 0.001$). Sensitivity analysis indicated olecranon osteotomy might be associated with longer duration of operation as compared with triceps-sparing approach after excluding the study conducted by Wang *et al*[25] (WMD: 22.02; 95% CI: 12.03–32.01; $P < 0.001$; $I^2 = 72.5\%$; $P = 0.026$). Moreover, olecranon osteotomy was associated with longer duration of operation if observational study was pooled, while no significant difference between groups for duration of operation after RCTs were pooled [Figure 4].

Blood loss

Data for the effect of olecranon osteotomy *vs.* triceps-sparing approach on blood loss were reported in four studies. The pooled result did not find significant difference between groups for the blood loss (WMD: 33.61; 95% CI: –18.35 to 85.58; $P = 0.205$) [Figure 5], and significant heterogeneity was seen ($I^2 = 97.6\%$; $P < 0.001$). Sensitivity analysis found the blood loss in olecranon osteotomy group was significantly increased

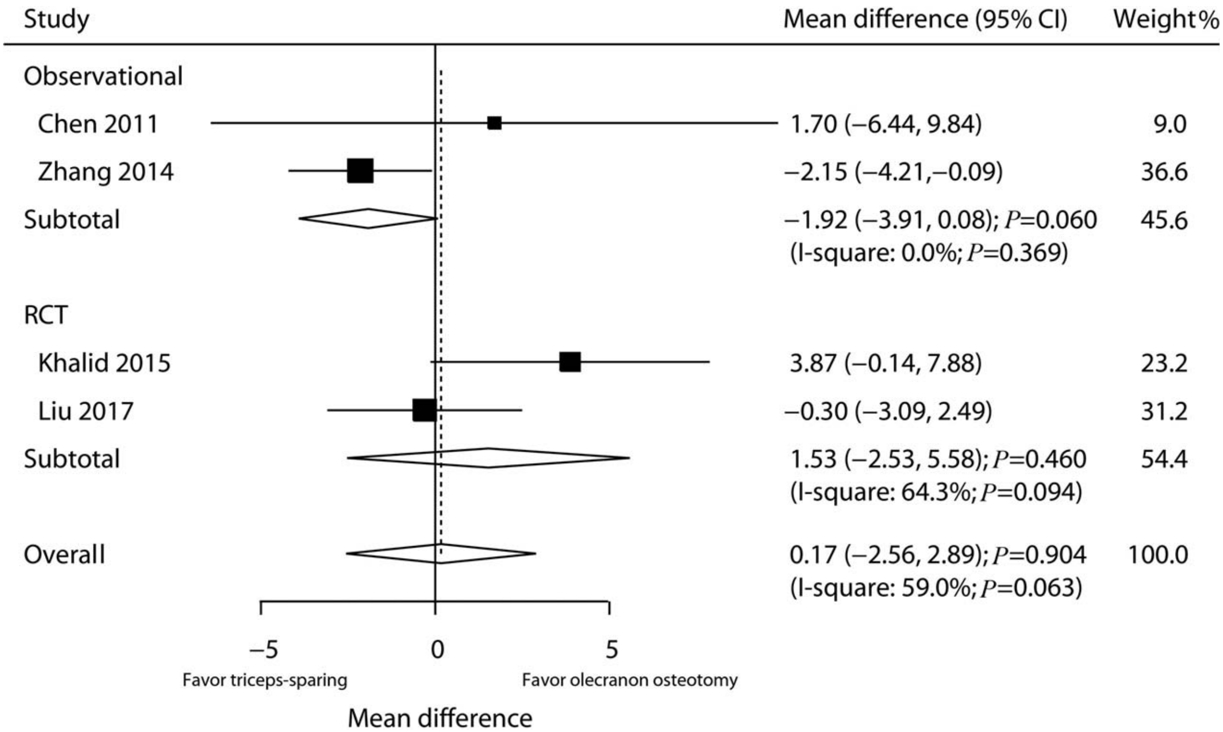

Figure 3: Effect of olecranon osteotomy *vs.* triceps-sparing approach on Mayo elbow performance score. CI: Confidence interval; RCT: Randomized controlled trial.

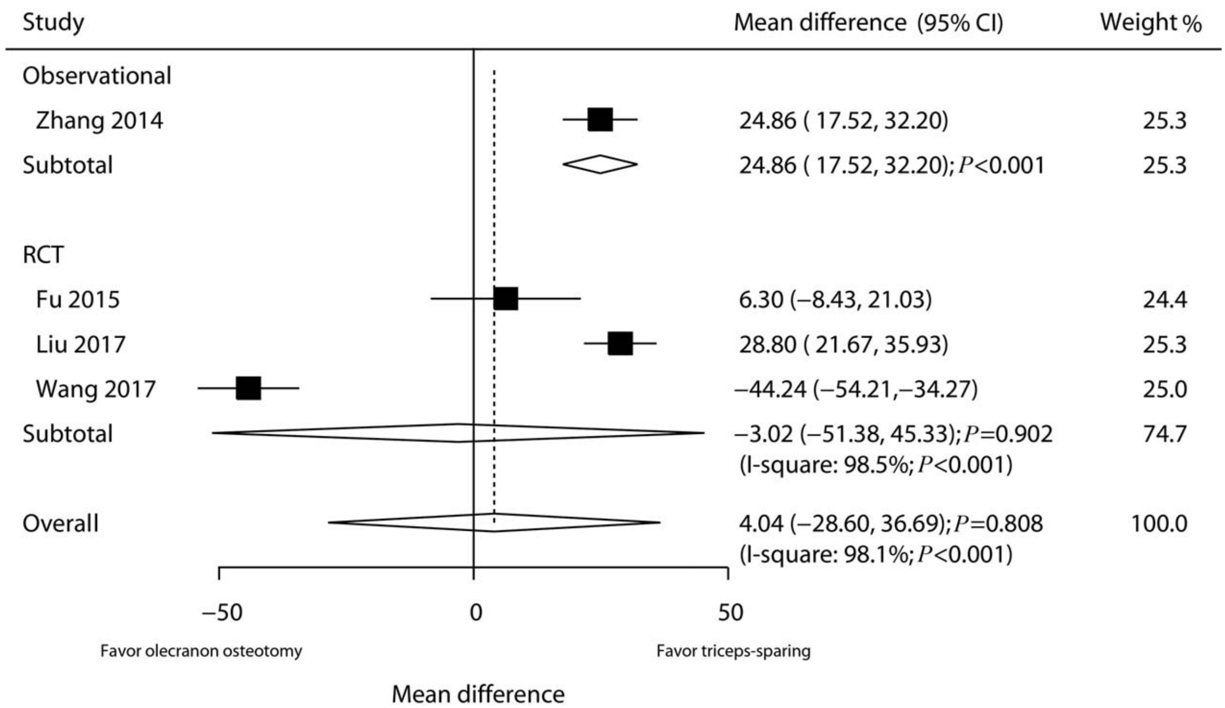

Figure 4: Effect of olecranon osteotomy *vs.* triceps-sparing approach on the duration of operation. CI: Confidence interval; RCT: Randomized controlled trial.

than those in triceps-sparing approach group after excluding the study conducted by Wang *et al*[25] (WMD: 57.09; 95% CI: 15.90–98.27; $P = 0.007$; $I^2 = 95.4\%$; $P < 0.001$). Moreover, olecranon osteotomy was associated with greater blood loss than triceps-sparing approach when observational study pooled. However, there was no significant difference between olecranon osteotomy and triceps-sparing approach for blood loss when RCTs were pooled [Figure 5].

Complications

Data for the effect of olecranon osteotomy *vs*. triceps-sparing approach on the risk of complications were

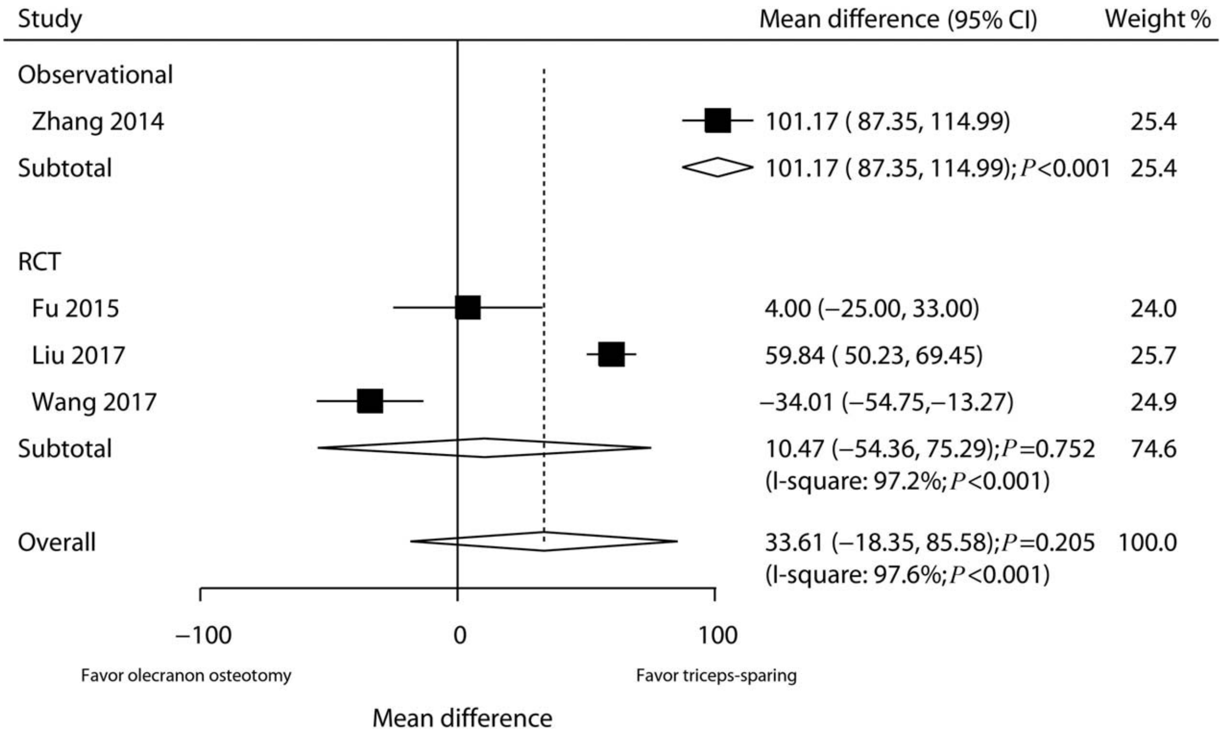

Figure 5: Effect of olecranon osteotomy *vs.* triceps-sparing approach on blood loss. CI: Confidence interval; RCT: Randomized controlled trial.

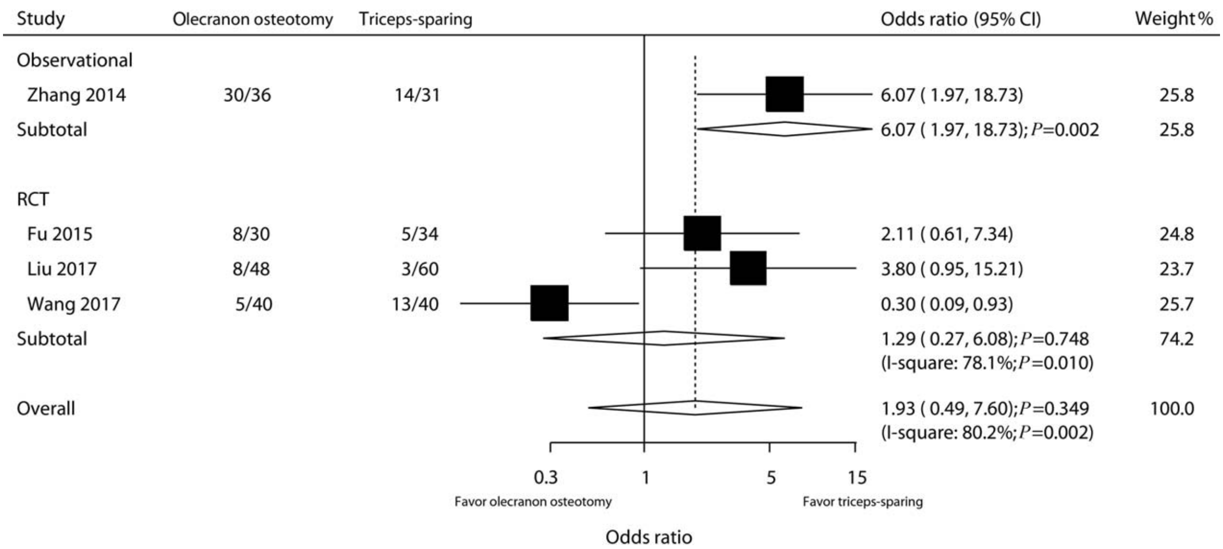

Figure 6: Effect of olecranon osteotomy *vs.* triceps-sparing approach on the risk of complications. CI: Confidence interval; RCT: Randomized controlled trial.

reported in four studies. No significant difference between groups for the risk of complications was detected (OR: 1.93; 95% CI: 0.49–7.60; $P = 0.349$) [Figure 6], and significant heterogeneity across included studies was observed ($I^2 = 80.2\%$; $P = 0.002$). The risk of complications in olecranon osteotomy group might increase when excluding the study conducted by Wang *et al*[25] (OR: 3.78; 95% CI: 1.85–7.74; $P < 0.001$; $I^2 = 0.0\%$; $P = 0.468$). Sub-group analysis found olecranon osteotomy was associated with an increased risk of complications when observational studies were pooled, while no significant difference between groups for complications after RCTs were pooled [Figure 6].

Publication bias

The funnel plot could not rule out potential publication bias for excellent/good elbow function [Figure 7]. The Egger ($P = 0.681$) and Begg ($P = 0.902$) tests also suggested no significant publication bias among included studies.

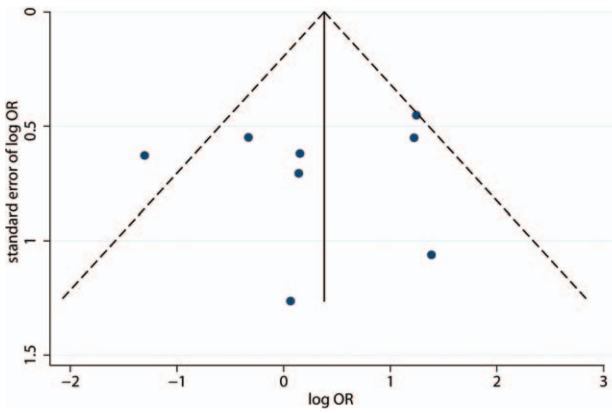

Figure 7: Publication bias for excellent/good elbow function.

Discussion

DHIF is a serious elbow joint trauma and widely occurs in young adults. This complex fracture is intraarticular and involves the surface of the joint. Therefore, surgical intervention is a standard strategy for management of DHIF because the prognosis for conservative treatment was poor. The use of triceps-sparing approach could fully reveal the humerus distal articular surface, obtain the shattering of the distal humerus fractures and block displacement by space between triceps brachialis and brachioradialis, or the biceps and the triceps internally and externally of the distal humerus, which could avoid the damage for the stretch elbow. However, triceps-sparing approach lacks sufficient reveal for the distal humerus. The use of olecranon osteotomy can overcome the above shortcoming, and get more attention in clinical practice. Therefore, this study aimed to compare the efficacy and safety of olecranon osteotomy *vs*. triceps-sparing approach before the open reduction and internal fixation for patients with DHIF. A total of 637 patients were recruited from nine studies and the pooled results suggested no significant differences between groups for excellent/good elbow function, Mayo elbow performance score, duration of operation, blood loss, and complications. However, sensitivity analyses found olecranon osteotomy might be associated with better excellent/good elbow function, while the duration of operation, blood loss, and complications in olecranon osteotomy group might be inferior than triceps-sparing approach.

A systematic review and meta-analysis conducted by Chen *et al* compared various surgical approaches on elbow functional outcomes for patients with DHIF.[6] They concluded olecranon osteotomy was superior than triceps-sparing approach in restoring joint function (OR: 2.38; $P = 0.009$). However, this analysis just contained four studies, and other efficacy and safety outcomes were not evaluated. Moreover, stratified analyses according to study or patients' characteristics were not illustrated. Therefore, the current systematic review and meta-analysis was conducted to compare the effectiveness of olecranon osteotomy *vs*. triceps-sparing approach for patients with DHIF.

The pooled result of this study found olecranon osteotomy did not yield beneficial effect than triceps-sparing approach on the incidence of excellent/good elbow function. However, this non-significant difference might be bias from the study conducted by Liu *et al*,[24] which specifically reported olecranon osteotomy was inferior than triceps-sparing approach for patients with DHIF. Olecranon osteotomy approach through turning the olecranon and triceps proximally and dislocating the elbow joint, then fully exposing the distal condyle of the humerus, played an auxiliary role in the reduction and fixation of fractures. The shortcoming of olecranon osteotomy was to cause artificial fracture of the olecranon in order to make the fracture site fully exposed, resulting in additional lateral injury. Moreover, internal fixation of the olecranon fracture was required after the DHIF, which was associated with longer operation time and the impaired elbow function or muscle strength.

Similarly, the summary results suggested no significant differences between groups for Mayo elbow performance score, duration of operation, blood loss, and complications. However, sensitivity analyses found olecranon osteotomy might be associated with longer operation time, higher blood loss, and excess risk of complications. These results were mainly biased by the study conducted by Wang *et al*,[25] specifically with low quality. They pointed out the treatment of DHIF by triceps-sparing approach did not yield excess damage of elbow flexion and extension function. Moreover, the injury was tiny and the local blood supply was better, then the ulnar and radial nerves could be repaired. Therefore, the elbow joint could be restored at the early stage with less post-operative complications.

The limitations of this study included: (1) both RCTs and observational studies were included, and the pooled results could be biased by uncontrolled confounded factors; (2) substantial heterogeneity among included studies for several results, which could not be fully explained by sensitivity and sub-group analyses; (3) the effect estimated in observational study was based on crude data, and the factors that could affect the prognosis of DHIF were not adjusted; (4) the severity of DHIF could affect the prognosis, while stratified analyses were not conducted because of the restricted information regarding the baseline characteristics of patients; and (5) similar to other traditional meta-analyses, individual patients data and publication bias could restrict the recommendation of this study.

This study did not find any benefit for olecranon osteotomy *vs*. triceps-sparing approach, while sensitivity analysis suggested the incidence of excellent/good elbow function might increase for patients treated with olecranon osteotomy. Moreover, potential harmful effects of olecranon osteotomy on operation time, blood loss, and complications were observed. These results needed to be further verified by prospective RCTs.

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Conflicts of interest

None.

References

1. Bhayana H, Pandey R, Dhammi IK, Baumann F, Bhatia U. Comparative study for assessment of functional outcome of intraarticular AO type C distal humerus fractures treated by parallel plating. Indian J Orthop 2019;53:190–195. doi: 10.4103/ortho.IJOrtho_298_18.
2. Yadav R, Nayak M, Maredupaka S, Sadiq M, Farooque K. Combined olecranon osteotomy and the posterior minimal invasive plate osteosynthesis approach for a concomitant injury of the humeral shaft and a distal intraarticular humerus fracture. Cureus 2019;11:e5966. doi: 10.7759/cureus.5966.
3. Munde SL, Bhatti MJ, Siwach RC, Gulia A, Kundu ZS, Bansal S, *et al*. Double tension band osteosynthesis in inter-condylar humeral fractures. J Clin Diagn Res 2015;9:RC08–RC11. doi: 10.7860/JCDR/2015/14198.6943.
4. Filardi V. Healing of tibial comminuted fractures by the meaning of an innovative intramedullary nail. J Orthop 2019;16:145–150. doi: 10.1016/j.jor.2019.02.026.
5. Kaiser T, Brunner A, Hohendorff B, Ulmar B, Babst R. Treatment of supra- and intra-articular fractures of the distal humerus with the LCP distal humerus plate: a 2-year follow-up. J Shoulder Elbow Surg 2011;20:206–212. doi: 10.1016/j.jse.2010.06.010.
6. Chen H, Li D, Zhang J, Xiong X. Comparison of treatments in patients with distal humerus intercondylar fracture: a systematic review and meta-analysis. Ann Med 2017;49:613–625. doi: 10.1080/07853890.2017.1335429.
7. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann T, Mulrow CD, *et al*. Mapping of reporting guidance for systematic reviews and meta-analyses generated a comprehensive item bank for future reporting guidelines. J Clin Epidemiol 2020;118:60–68. doi: 10.1016/j.jclinepi.2019.11.010.
8. Adie S, Harris IA, Naylor JM, Mittal R. CONSORT compliance in surgical randomized trials: are we there yet? A systematic review. Ann Surg 2013;258:872–878. doi: 10.1097/SLA.0b013e31829664b9.
9. Wells G, O'Connell D. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Ottawa (ON): Ottawa Hospital Research Institute; 2009. Available from: http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm. [Accessed January 10, 2020]
10. Ades AE, Lu G, Higgins JP. The interpretation of random-effects meta-analysis in decision models. Med Decis Making 2005;25:646–654. doi: 10.1177/0272989X05282643.
11. Doi SAR, Furuya-Kanamori L, Thalib L, Barendregt JJ. Meta-analysis in evidence-based healthcare: a paradigm shift away from random effects is overdue. Int J Evid Based Healthc 2017;15:152–160. doi: 10.1097/XEB.0000000000000125.
12. Deeks J, Higgins J, Altman D. Higgins J, Green S. Analyzing data and undertaking meta-analyses. Cochrane Handbook for Systematic Reviews of Interventions 501. Oxford, UK: The Cochrane Collaboration; 2008.
13. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003;327:557–560. doi: 10.1136/bmj.327.7414.557.
14. Liu J, Zhang HX. Significant study of population stratification, sensitivity analysis and trim and fill analyses on GBA mutation and Parkinson's disease. Am J Med Genet B Neuropsychiatr Genet 2014;165B:96–102. doi: 10.1002/ajmg.b.32214.
15. Altman DG, Bland JM. Interaction revisited: the difference between two estimates. BMJ 2003;326:219. doi: 10.1136/bmj.326.7382.219.
16. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ 1997;315:629–634. doi: 10.1136/bmj.315.7109.629.
17. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. Biometrics 1994;50:1088–1101. doi.org/10.2307/2533446.
18. Pajarinen J, Bjorkenheim JM. Operative treatment of type C intercondylar fractures of the distal humerus: results after a mean follow-up of 2 years in a series of 18 patients. J Shoulder Elbow Surg 2002;11:48–52. doi: 10.1067/mse.2002.119390.
19. Liu YK, Xu H, Liu F, Wang YH, Tao R, Cao Y, *et al*. Treatment of type C intercondylar fractures of distal humerus using dual plating. Chin J Surg 2009;47:892–895. doi: 10.3760/cma.j.issn.0529-5815.2009.12.004.
20. Chen G, Liao Q, Luo W, Li K, Zhao Y, Zhong D. Triceps-sparing versus olecranon osteotomy for ORIF: analysis of 67 cases of intercondylar fractures of the distal humerus. Injury 2011;42:366–370. doi: 10.1016/j.injury.2010.09.004.
21. Zhang C, Zhong B, Luo CF. Comparing approaches to expose type C fractures of the distal humerus for ORIF in elderly patients: six years clinical experience with both the triceps-sparing approach and olecranon osteotomy. Arch Orthop Trauma Surg 2014;134:803–811. doi: 10.1007/s00402-014-1983-y.
22. Fu W, Xu L, Zhang B. Clinical comparison of the olecranon osteotomy approach and after bilateral triceps approach fixation in the treatment of intercondylar distal humeral fracture. Shaanxi Med J 2015;44:76–78. doi: 10.3969/j.issn.1000-7377.2015.01.029.
23. Khalid MU, Saeed KM, Akhter M. A comparison of functional outcome of intercondylar fracture of distal humerus managed by olecranon osteotomy approach versus triceps sparing approach in adults. J Pak Med Assoc 2015;65:S119–122.
24. Liu Y, Su C, Zhang W. Effect observation of internal and external approach of triceps brachii combined with open reduction and internal fixation in treatment of humeral intercondylar fracture. Clin Misdiag Misther 2017;30:57–60. doi: 10.3969/j. issn.1002-3429.2017.06.021.
25. Wang W, Ma W, Huang Y. Clinical comparison of the treatment of intercondylar fracture of humerus by combined approach of triceps and olecranon. Chin J Clin Res 2017;30:366–368. doi: 10.13429/j.cnki.cjcr.2017.03.024.
26. Tan D, Wei N, Jin M. Clinical study of two surgical approaches in the treatment of intercondylar fractures of the humerus. J Bone Joint Injuries 2018;18:127–128. doi: 10.19589/j.cnki.issn1004-6569.2018.18.127.

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