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Original article

Deltoid-split approach versus deltopectoral approach for proximal humerus fractures: A systematic review and meta-analysis

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ABSTRACT

Purpose: To investigate the evidence of deltoid-split approach (DS) versus deltopectoral approach (DP) in treatment of proximal humerus fractures from current RCT and prospective literatures.
Methods: The electronic literature database of Pubmed, Embase, and Cochrane library was searched at December 2017. The data complications (including implant failure, humeral head necrosis, infection, radiological adverse events, nonunion rate, subacromial impingement, and damage of the axillary nerve), functional outcomes (including Constant, NEER, DASH, ADL, VAS score), operation time, hospital stay and intraoperative blood loss were extracted and analyzed by STATA 11.0 software.
Results: Three RCTs and three prospective comparative studies were included in this meta-analysis. The meta-analysis showed that the DS group had a significantly low humeral head necrosis rate and short operation time. No significant difference was found in total complication rate, functional outcome, and other Perioperative parameters between DS and DP groups.
Conclusion: The prospective evidence suggested that DS approach for proximal humerus fractures had less humeral head necrosis and short operation time than DP approach. Both DS and DP approach had similar results in functional outcomes, total complication, VAS, and hospital stay.

1. Abbreviations

DS	deltoid-split approach
DP	deltopectoral approach
DASH	Disabilities of the Arm, Shoulder and Hand score
ADL	activities of daily living
VAS	Visual analog scale
NA	not available
ORIF	open reduction internal fixation
MIPPO	minimal invasive percutaneous plate osteosynthesis
RCT	randomized controlled trials
PCs	prospective comparative study
RR	relative risk
CI	confidence interval
SMD	Standardized Mean Difference
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SD	standard deviation

2. Introduction

Fractures of the proximal humerus are usually attributable to osteoporosis [1] and are mostly caused by low-energy trauma [2]. A 3 fold increase of proximal humeral fractures is expected by 2030 [3]. The optimal treatment for proximal humeral fractures is controversial [4]. It includes conservative treatment, open reduction internal fixation (ORIF), minimal invasive percutaneous plate osteosynthesis (MIPPO), intramedullary nailing and arthroplasty reported in literature [5,6]. But a basic conclusion supported by comparative study [7,8], review [9,10] and even meta-analysis [11]

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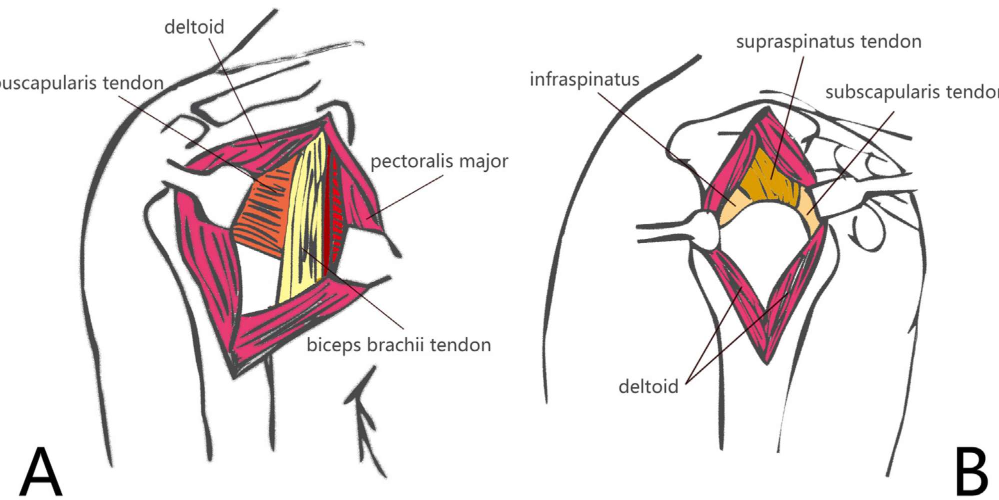

Fig. 1. Schematic diagram for deltopectoral approach (DS) and deltoid-split approaches (DP).

has been drawn that surgical treatment can better of function and health-related quality, compared with the nonsurgical treatment.

Conventional surgical methods of ORIF use the deltopectoral approach (DP) as Fig. 1A. However, some authors have argued that this approach involves extensive soft tissue dissection and muscle retraction to gain adequate exposure to the lateral aspect of the humerus [12]. As an alternative, a less invasive, deltoid-split (DS) approach (Fig. 1B) has been described with the goal of minimizing local soft tissue trauma [13]. However, the deltoid-split approach using the MIPPO technique was recently reported to associated with a risk of damage to blood supply of the humerus head [14] and axillary nerve [15].

Which surgical approach has more advantages? Some RCTs [16–18], prospective comparative study (PCs) [14,19] and retrospective study [20,21] were developed trying to answer this question, but the conclusions were not completely consistent. Based on the current evidence, we performed this meta-analysis to compare the DS approach with the DP approach for the management of proximal humerus fracture and expected to draw a certain and meaningful conclusion for this question.

3. Methods

This systematic review and meta-analysis was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement [22]. No primary personal data will be collected; therefore, no additional ethical approval needs to be obtained.

3.1. Search strategy

Two authors (The first and second authors) independently searched the electronic literature database of Pubmed, Embase, and Cochrane library, without language limitation at December 2017. The key words using a combination of different terms and synonyms were used as follows: “proximal humeral fracture”, “deltoid-splitting”, “deltopectoral”, and “approach”. In addition, the reference lists of previously published randomized trials, review articles, and meta-analyses were manually searched for additional eligible studies. Related articles and reference lists were searched to avoid original miss.

3.2. Eligibility criteria

The study was included in this meta-analysis if it was:

- prospective randomized controlled trial (RCT) or nonrandomized prospective comparative study (PCs);
- it compared the clinical outcomes deltoid-splitting approach versus deltopectoral approach for the proximal humeral fracture;
- it was with a follow-up term of at least 12 months.

Exclusion criteria were as follows:

- respective studies, case series, case report, and review articles;
- follow-up of less than 12 months;
- duplicated publications from the same hospital or research center.

3.3. Selection of literature

We used the PRISMA flow diagram to select the included studies; the results of literature search were imported into the software Endnote X7. Two authors (the third and fourth author) independently assessed the potentially eligible studies. Firstly, the titles and abstracts were screened to exclude the duplicated and apparently irrelevant ones or those that do not meet our inclusion criteria. After then, the remaining potential studies were full-text downloaded and reviewed. Any disagreement between two above authors was sent and discussed with the third independent author (the sixth author).

3.4. Data extraction

Two reviewers (the first and fifth author) independently extracted data, and another reviewer (the six author) checked the consistency between them. A standard form was used; the extracted items included the following:

- the general study information, for example, the authors, publishing date, country, study design, sample size, age, gender, follow-up term;
- perioperative parameters, including operative time, estimated blood loss and length of hospital stay;

- clinical outcomes, including visual analog scale (VAS) of shoulder pain and wound pain (0 = no pain at all to 10 = intolerable pain); Constant-Murley score [23] or Disabilities of the Arm, Shoulder and Hand (DASH) [24] for range of shoulder motion; Activities of daily living (ADL) were recorded according to the ADL score in line with Lawton and Brody [25];
- complications, including implant failure (screw loosening, screw cutout and plates breakage), humeral head necrosis, infection, inadequate reduction (varus malalignment and secondary displacement of a greater tuberosity fragment), nonunion, subacromial impingement and axillary nerve damage.

For continuous outcomes, we extracted the mean and SD (standard deviation) and participant number will be extracted. For dichotomous outcomes, we extracted the total numbers and the numbers of events of both groups. The data in other forms was recalculated when possible to enable pooled analysis.

3.5. Quality assessment of included studies

Because both RCTs and prospective comparative studies (PCs) were included, the risk of bias in included RCT studies was assessed using the Risk of Bias Tool recommended by the Cochrane Collaboration [26]. PCs were evaluated using the Newcastle-Ottawa Scale [27].

3.6. Statistical analysis

The data was collected and input into the STATA software (version 11.0; StataCorp, College Station, TX) for meta-analysis. A random-effects model was applied when heterogeneity was detected or the statistical heterogeneity was high ($P < 0.05$ or $I^2 > 50\%$). Otherwise, a fixed-effects model was used ($P \geq 0.05$ or $I^2 \leq 50\%$). For heterogeneity data, sensitivity analysis was involved to remove one study and evaluate whether the other results would be markedly affected. Relative risk (RR) was calculated for dichotomous outcomes such as complications, standard mean difference (SMD) was calculated for continuous outcomes such as operative time, estimated blood loss, length of hospital stay, and function outcomes.

4. Results

4.1. Included studies

A total of 2635 potential records were identified through Medline ($n = 1176$), Embase ($n = 1435$), and Cochrane library ($n = 24$). After removal of duplicates, 1546 articles were screened for relevance on the basis of the title and abstract. Of the 17 articles that were possibly eligible for inclusion, 11 were excluded for reasons of "the papers were review or retrospective studies" and some other reasons (details were showed in Fig. 2). The remaining 6 studies (3 RCT and 3 nonrandom prospective comparative studies) were included in this meta-analysis.

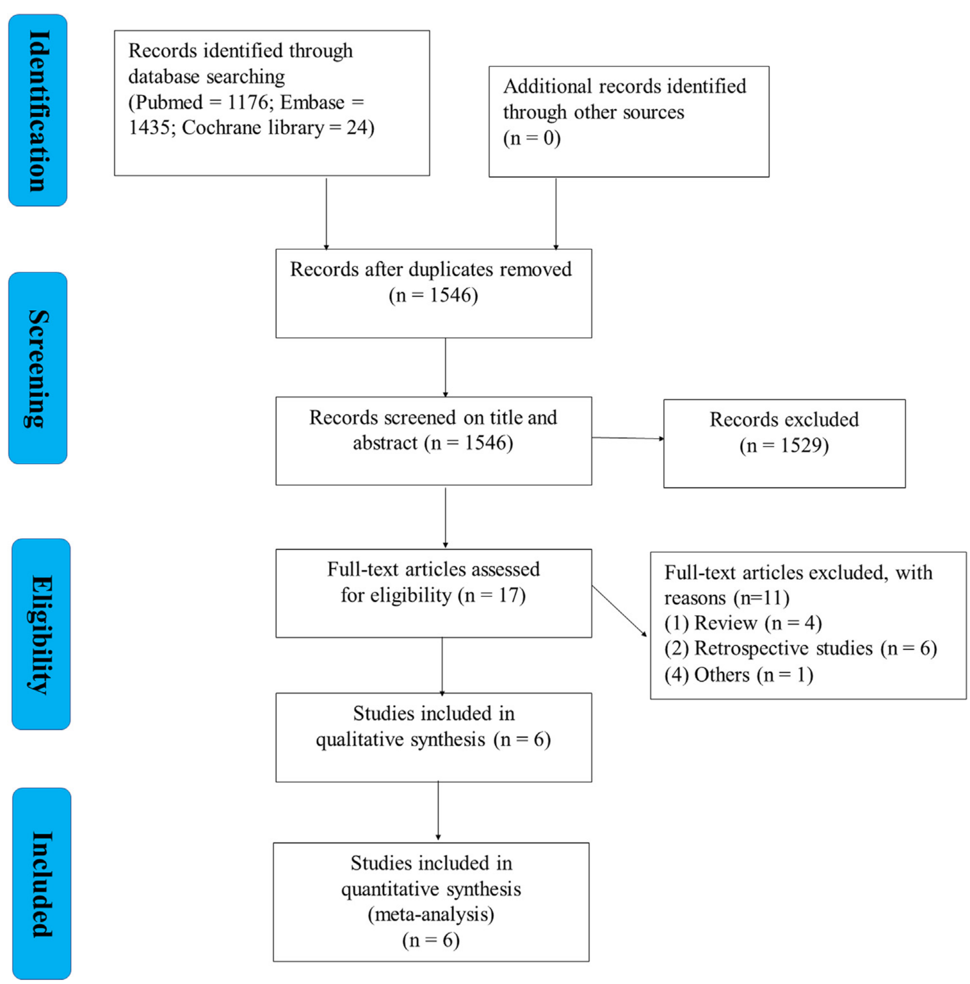

Fig. 2. Flowchart of study selection.

Table 1
The characteristics of the included studies.

Study	Year	Location	Study design	Patients enrolled	Age (years)	Gender(M/F)	Follow-up term(months)	Operation time
Buecking et al.	2014	Germany	RCT	DS: 60 DP: 60	DS: 69 ± 1.53 DP: 67 ± 2.04	DS: 12/48 DP: 16/44	12	DS: 62 ± 2.56 DP: 67 ± 3.32
Zhao et al.	2017	China	RCT	DS: 17 DP: 19	DS: 64.3 ± 6.7 DP: 63.6 ± 5.0	DS: 9/8 DP: 12/7	24	DS: 53.6 ± 7.3 DP: 61.4 ± 7.0
Martetschl et al.	2012	Germany	RCT	DS: 37 DP: 33	DS: 59 ± 13.5 DP: 56 ± 9.95	DS: 13/24 DP: 21/12	DS: 20 DP: 48	DS: 107 DP: 106
Hepp et al.	2008	Germany	PCT	DS: 39 DP: 44	DS: 64 ± 17.9 DP: 65.5 ± 15.1	DS: 12/27 DP: 7/37	12	DS: 66.5 ± 17.8 DP: 85.9 ± 28.1
Bandalo et al.	2014	Croatia	PCT	DS: 25 DP: 42	DS: >65 DP: >65	NA	14.8	NA
Fischer et al.	2016	Germany	PCT	DS: 20 DP: 30	DS: 57.6 ± 13.5 DP: 60.6 ± 14.5	DS: 10/20 DP: 6/14	DS: 22.8 ± 17.0 DP: 20.7 ± 15.2	NA

DS: deltoid-splitting group; DP: deltopectoral group; M/F: male/female; NA: Not available.

Table 2
Risk of bias assessment of the RCTs.

Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias
Buecking et al.	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Zhao et al.	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Martetschl et al.	High risk	Unclear risk	Low risk	Unclear risk	Low risk	Low risk	Low risk

Table 3
Risk of bias assessment of the PCs.

Study	Selection				Comparability	Outcome			Total score
	Exposed cohort	Nonexposed cohort	Ascertainment of exposure	Outcome of interest		Assessment of outcome	Length of follow-up	Adequacy of follow-up	
Hepp et al.	*	*	*	*	**	*	*	*	9
Bandalovi et al.	*	*	*	*	–	*	*	*	7
Fischer et al.	*	*	*	*	**	*	*	*	9

Risk of bias was assessed with use of the Newcastle-Ottawa Scale. "*" means a score of 1; "**" means a score of 2; the total score of this scale is 9. A higher overall score corresponds to a lower risk of bias; a total score of 5 or less indicates a high risk of bias.

4.2. Characteristics and qualifications of included studies

The characteristics of all five included studies were summarized and shown in Table 1. All the 6 included studies [14,16–19,28] were RCT and prospective comparative studies without random. They were from three different countries (1 from China, 3 from Germany and 1 from Croatia) and all of them were published between 2008 and 2017. Total of 198 participants in DS group and 228 in DP group were included in this meta-analysis. Risk of bias assessment of RCTs was presented in Table 2. When using the Newcastle-Ottawa Scale to assess the risk of bias of the PCs, the total scores were all higher than 5 indicating a low risk of bias (Table 3).

4.3. Complications

Complications including implant fail (screw loosening, screw cutout and plates breakage), humeral head necrosis, infection, inadequate reduction (varus malalignment and secondary displacement of a greater tuberosity fragment), nonunion and subacromial impingement were reported. The meta-analysis showed that there was no significant difference between both DS and DP groups, with RR = 0.74 (95% CI: 0.50, 1.08), while, the heterogeneity among studies was very low ($I^2 = 0\%$, $P = 0.95$) (Fig. 3).

4.3.1. Implant failure

There were four papers [14,16,18,19] reporting the complications. It included screw loosening, screw cutout and plates breakage. Another two studies [17,28] had no similar complication. The meta-analysis showed that there was no significant difference between both DS and DP groups, with RR = 0.98 (95% CI: 0.50, 1.94), with no heterogeneity ($I^2 = 0\%$, $P = 0.45$) (Fig. 3). Three studies [16,18,19] reported they did revision with a prosthesis or removal the implant. Bandaloviü, et al. [14] found intraarticular screw placement was seen in 1 patient in DP group during follow-up, but they did not mention process of dealing with it.

4.3.2. Humeral head necrosis

Four studies [14,18,19,28] reported of humeral head necrosis during the fellow-up. The meta-analysis showed that there was significant difference between both DS and DP groups, with RR = 0.28 (95% CI: 0.08, 0.94, $P = 0.04$), with no heterogeneity ($I^2 = 0\%$, $P = 0.87$) (Fig. 3). Two of 198 (1%) patients in the DS group and 11 of 228 (4.8%) patients in the DP group developed the head necrosis.

The method for dealing with patients with a head necrosis differed among the studies. Martetschlager, et al. [18] used the additional criteria of most relevant predictors of ischemia according to Cruess [29] and Hepp, et al. [19].These predictors were mostly based on the determining factors which had been reported by Hertel et al. [30]. Unfortunately, most of the studies did not mention any further treatment for this complication, just Fischer, et al. [28] report One woman in the DP group showed radiologic signs of avascular head necrosis without suffering from any functional limitation.

4.3.3. Infection

The rate of infection is very low in the two groups: 1 of 198 (0.5%) in DS group, 4 of 228 (1.8%) in DP group. Just three studies [16–18] reported this adverse event, other three studies [14,19,28] found

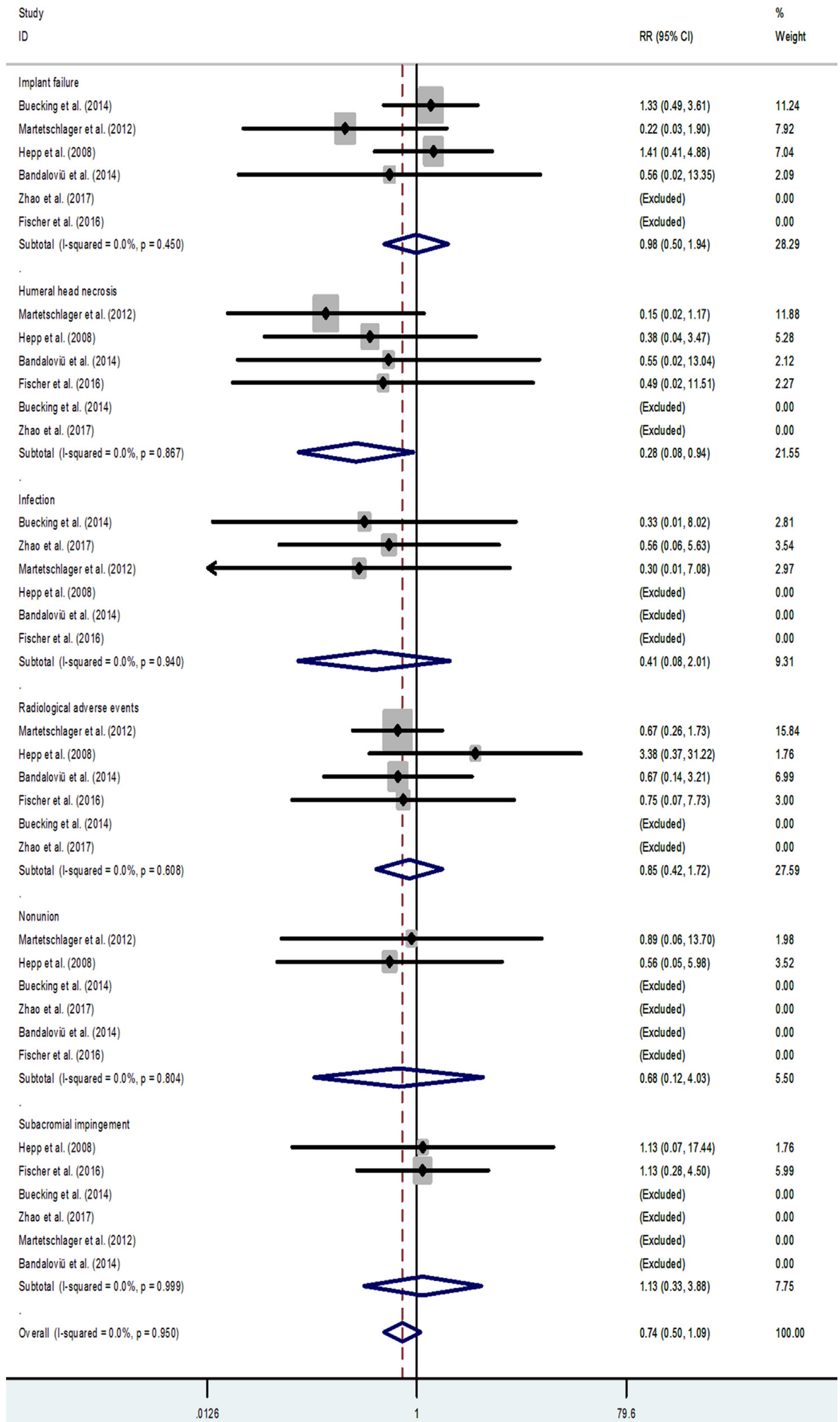

Fig. 3. Forest plot showing the meta-analysis of the complications.

Table 4
Summary of the outcomes of function scores.

Variable	Number of study	First author	DS cases	Mean	SD	DP cases	Mean	SD	P
Constant score (6 weeks)	1	Buecking	48	46	2.04	42	47	7.14	0.62
Constant score (3 months)	1	Hepp	39	57.9	16.6	44	49.6	17.9	**0.02***
Constant score (6 months)	2	Buecking	48	68	2.81	42	64	3.32	0.41
		Hepp	39	69.4	13.8	44	71.4	20.9	0.4
Constant score (12 months)	3	Buecking	48	81	3.32	42	73	4.34	0.13
		Zhao	17	88.8	1	19	86.9	2.1	**0.001***
		Hepp	39	73.1	12.1	44	81	18.7	**0.004***
Constant score (24 months)	2	Martetschlager	37	75.1	14.8	33	72.8	15.7	0.7
		Fischer	20	81.6	16.1	30	76.3	18.6	0.37
NEER score (12 months)	1	Zhao	17	87.4	1.2	19	85.7	2.6	**0.019***
DASH (12 months)	1	Hepp	39	14.6	NA	44	14.6	NA	0.43
DASH (24 months)	2	Martetschlager	37	14.1	No	33	13.8	No	0.94
		Fischer	20	21.1	8.6	30	20.1	20.3	0.68
ADL (6 weeks)	1	Buecking	48	13	0.77	42	12	1.02	0.49
ADL (3 months)	1	Hepp	39	14.5	3.51	44	12.5	3.2	**0.01***
ADL (6 months)	2	Buecking	48	19	0.77	42	15	2.55	0.82
		Hepp	39	16.9	2.5	44	16.2	3.5	0.6
ADL (12 Months)	2	Buecking	48	18	0.77	42	17	1.28	0.31
		Hepp	39	17.7	2.7	44	17.5	2.9	0.9
ADL (24 Months)	1	Martetschlager	37	19	NA	33	19	NA	0.6
VAS (6 weeks)	1	Buecking	48	3.6	0.28	42	3.9	0.31	0.56
VAS (6 months)	2	Buecking	48	2.7	0.33	42	3.1	0.38	0.45
		Zhao	17	3.1	1.3	19	3.2	1.3	0.73
VAS (12 Months)	1	Buecking	48	1.8	0.31	42	2.5	0.41	0.15

ADL: activities of daily living; VAS: visual analog scale; DASH: Disabilities of the Arm, Shoulder and Hand score; NA: not available; The asterisk and bold present mean there was a significant difference between DP and DS group.

there was no infection during the fellow-up. The meta-analysis showed that there was no significant difference between both DS and DP groups, with RR = 0.41 (95% CI: 0.08, 2.01), with no heterogeneity (I^2 = 0%, P = 0.94) (Fig. 3).

Different processing method dependent on different infection. Buecking et al. [16] made a second surgery to remove the plate, thus the deep infection was under control. The infection in Martetschl et al. [18] was treated successfully by revision surgery and antibiotic therapy. While Zhao et al. [17] did not mention elective treatment operations for the infections.

4.3.4. Radiological adverse events

We determine the radiology adverse events as inadequate reduction, varus malalignment and secondary displacement. Four studies [14,18,19,28] reported the radiology complication. There was no significant difference between both DS and DP groups by the meta-analysis RR = 0.85 (95% CI: 0.42, 1.72), with no heterogeneity (I^2 = 0%, P = 0.61) (Fig. 3).

All the 4 studies referred a varus malalignment during the fellow-up, but none of them mentioned the way to deal with it. Hepp et al. [19] and Bandalo et al. [14] reported a secondary displacement of a greater tuberosity fragment, a revision surgery in DS group was performed in Hepp et al.'s study.

4.3.5. Other complications

Two studies [18,19] reported the data of nonunion rate, the meta-analysis showed that there was no significant difference between both DS and DP groups, with RR = 0.68 (95% CI: 0.12, 4.03), with no heterogeneity (I^2 = 0%, P = 0.94) (Fig. 3). One research [18] did not perform revision surgery due to without pain or clinical restrictions. The nonunion in another one [19] was treated by reosteosynthesis combined with cancellous grafting after 6 and 8 months.

Subacromial impingement was reported in two papers [19,28] as complication. There was no significant difference between both DS and DP groups by the meta-analysis RR = 1.13 (95% CI: 0.33, 3.89), with no heterogeneity (I^2 = 0%, P = 0.99) (Fig. 3), while the authors did not mention how to solve this problem.

No damage of the axillary nerve was detected on clinical neurological examination in all the studies. One study [14] reported the deltoid muscles were weak initially, however returned to normal after rehabilitation, but the author did not mention which group happened.

4.4. Functional outcomes

As detailed in Table 4, at the postoperative 6 weeks [16], 6 months [16,19] and 2 years [18,28], the functional outcomes of Constant (Fig. 4A) and DASH (Fig. 4B) score in the DS group did not better than the DP groups. However, one study [19] reported the Constant score in at the postoperative 3 months was significant different (Fig. 4A). At the postoperative 12 months, most studies found that the DS group did better than the DP group significantly, regardless of which function scoring system was used (Constant [17,19] and NEER [17] score) (Fig. 4A). However, when the meta-analysis was made, because of detecting the heterogeneity with P = 0.000, I^2 = 96.5%, the random-effect model was performed and there was no significant difference between the two groups (SMD = 0.9, 95% CI −0.78 to 2.59; P = 0.293) (Fig. 5).

For the variable of ADL [16,18,19] (Fig. 4C) and VAS [16,17] (Fig. 4D), most studies found there was no significant difference between both DS and DP groups regardless of the postoperative time (6 weeks, 3, 6, 12 and 24 months). Just one study [19] found there was significant difference of ADL with postoperative 3months between the two groups.

4.5. Perioperative parameters

Operation time, hospital stay and intraoperative blood loss were defined as the perioperative parameter. Four studies [16–19] could provide data for the operation time, but one of them [18] could provide standard format for calculating the SMD, but with standard deviation was not available. Then, the meta-analysis was made, because of detecting the heterogeneity with P = 0.018, I^2 = 75%, the random-effect model was performed and a significant difference was found between the two groups (SMD = −1.25, 95% CI −1.53 to −0.97; P = 0.018) (Fig. 6). To eliminate the heterogeneity and obtain

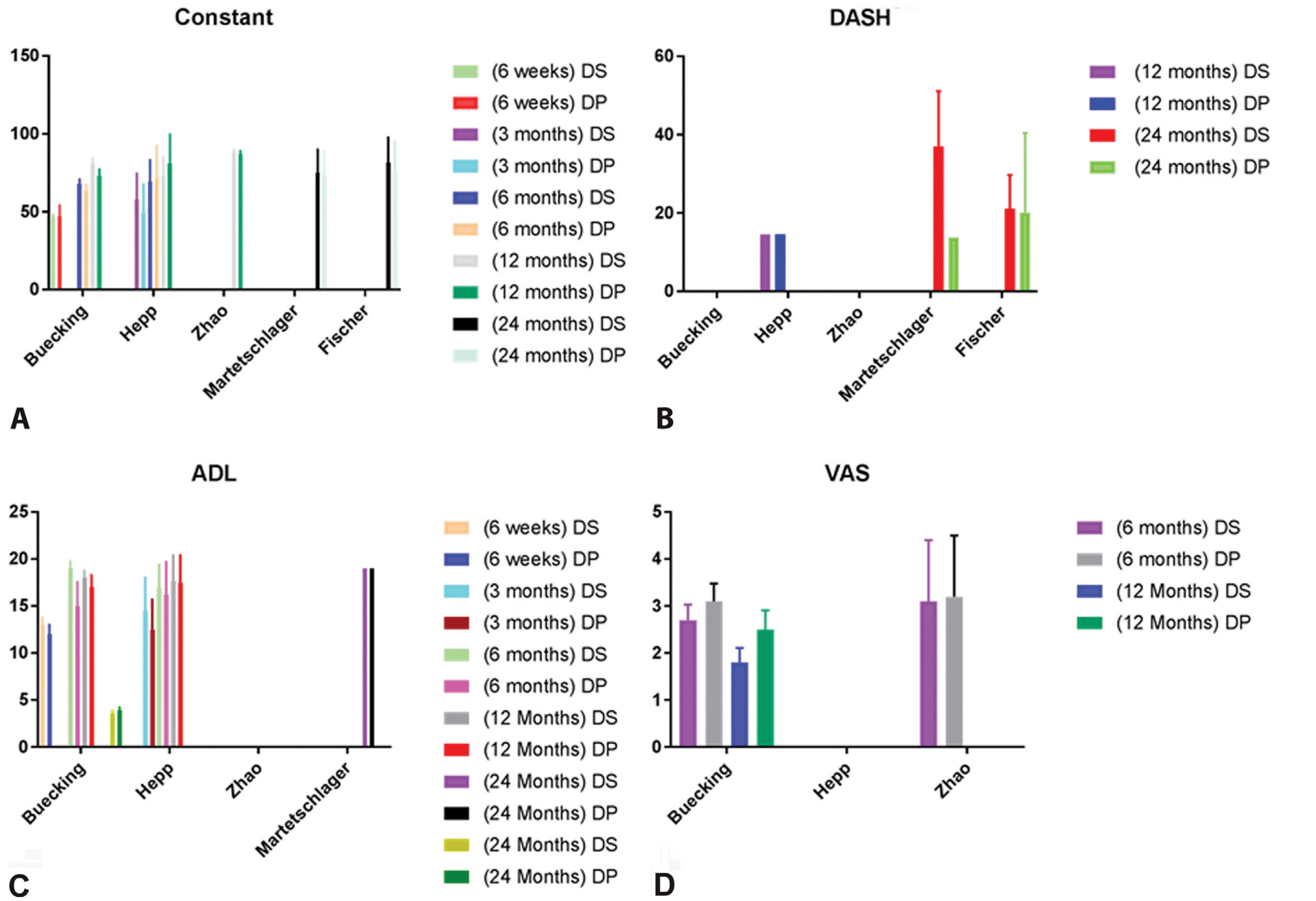

Fig. 4. Histogram of the comparison of the two groups of functions. A. Constant score. B. Disability Arm, Shoulder Hand (DASH). C. Activities of daily living (ADL). D. Visual Analogue Scale (VAS).

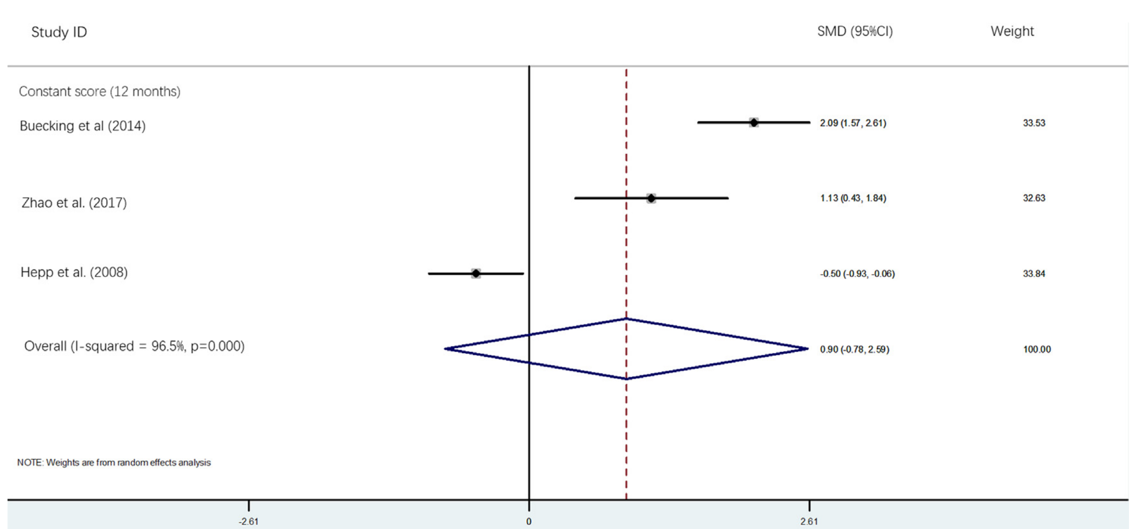

Fig. 5. Forest plot showing the meta-analysis of the Constant Score at the postoperative 12 months with a random-effect model.

a more objective result, we performed a sensitivity analysis [16]. After excluding the study of Buecking et al. [16], the heterogeneity disappeared ($P=0.514$, $I^2=0\%$), then we found operation time in the DS group was significantly lower than that in the DP group (SMD −0.89, 95% CI −1.27 to −0.52; $P=0.001$) using the fixed effect model (Fig. 7).

About the intraoperative blood loss was reported by Zhao et al. [17]. They found there was a significant difference between them (129.2 ± 17.8 vs. 145.3 ± 23.0 ml $P=0.026$), the DS group show less blood loss. Buecking et al. [16] reported the hospital stay(day), the two groups did the similar hospital stay($P=0.86$).

5. Discussion

Proximal humerus fractures are common [2], and there was no meta-analysis in the previous study to compare the two

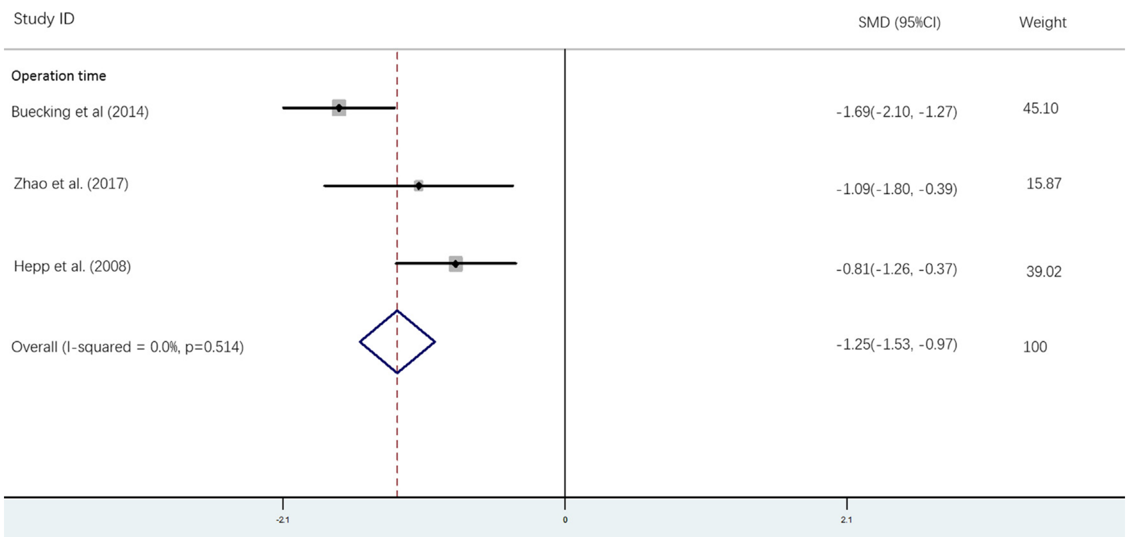

Fig. 6. Forest plot showing the meta-analysis of the operation time.

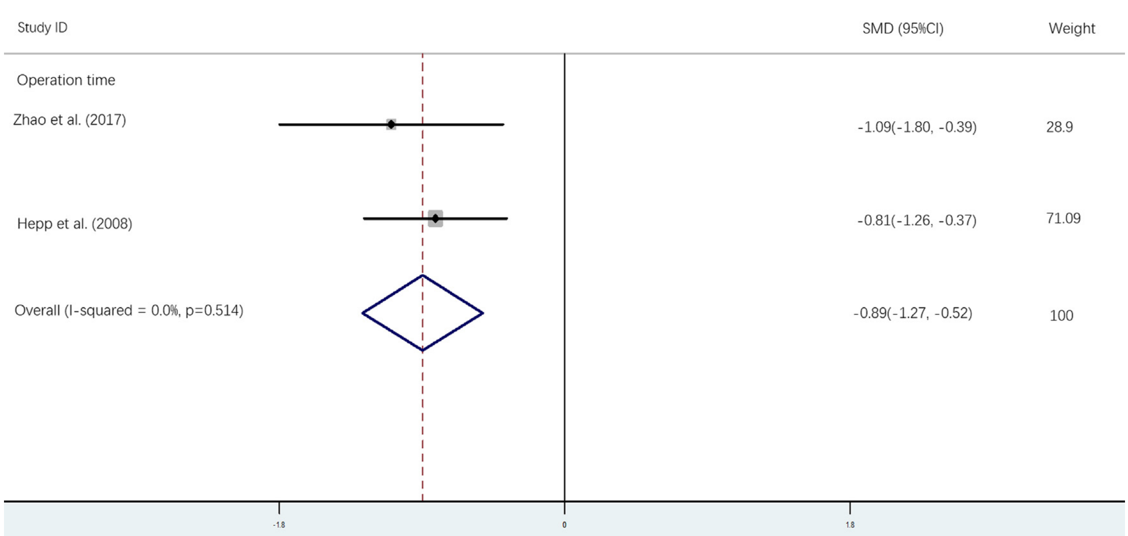

Fig. 7. Forest plot showing the meta-analysis of the operation time excluding the study of Buecking et al.

approaches. According to our pooled data, the meta-analysis results showed there was a better result for DS group about the humerus head necrosis and function outcome in 12 months. While, one RCT [17] showed the intraoperative blood loss was more less in the DS group. What's more, the result did not show any damage of the axillary nerve in all the studies. These findings indicate that through a DS approach, we not only can reduce the problems of the head necrosis and operation blood loss but also achieve the better functional outcomes with the similar operation time and other complications compared with the DP approach.

The humeral head articular surface has a tenuous blood supply [31,32]. The arcuate branch of the anterior humeral circumflex artery provides a significant proportion of the flow to the humeral head articular surface in a retrograde fashion. This is akin to the lateral epiphyseal branch of the medial femoral circumflex artery that supplies the femoral head. The traditional surgical approach (DP group) will separate more soft tissue, resulting in an increased surface blood loss, thereby increasing the risk of humeral head necrosis. The DS approach provides direct access to the lateral humeral bald spot obviating the need for circumferential dissection and potential vascular disruption either anteriorly or posteriorly [33]. What's more, plating through a minimally invasive anterolateral acromial approach allows direct access to the appropriate plating zone, a bare spot between the humeral head – penetrating vessels from the anterior and posterior circumflex system. The meta-analysis showed the low rate in the DS group (2/198, 1%), it was comparable with the Neviaser et al.'s study [34]. They used the anterolateral approach, the anterior deltoid raphe was split, while no patient suffered complete osteonecrosis (0%) and only one patient suffered partial necrosis (2.8%) of the humeral head.

The risk of damaging the axillary nerve in less invasive surgery is a frequently discussed and feared problem [35]. To protect the axillary nerve, Buecking et al. [16] indicated the nerve with the index finger in the subdeltoid bursa and its course was marked on the skin. Additionally, some used a five-hole plate that was inserted with its tip contacting the bone, and Ruchholtz et al. [36] fixed screws in the three distal holes, far away from the axillary nerve. In our meta-analysis, just one reported the deltoid muscles were weak initially, however returned to normal after rehabilitation. With the progress of surgical techniques and internal fixation development, we believe this complication will be less, and will not be a limitation of the DS approach for Proximal humerus fractures.

Yves et al. [37] reported a prospective analysis of minimally invasive plating in proximal humerus fractures. They found this minimally invasive procedure resulted in a shorter operation time and may have reduced the avascular necrosis rate. In our meta-analysis, the DS approach showed a better result in the operation time compared with the DP approach. While, less avascular necrosis in the DS group. In contrast to the commonly used delta-pectoral standard approach, the trans-deltoid MIPO approach provides a direct visualisation of the plating zone under minimal soft tissue dissection and involves simpler exposure of the tuberosity. Furthermore, because no retractors are placed dorsal to the humeral shaft, no distracting malalignment results, and restoring the anatomic head-shaft axis using the DS approach is easier. However, there was just two studies for the meta-analysis after the sensitivity analysis. The evidence that DS approach is better for operation time still needs further research.

Less soft tissue manipulation and reduced exposure, for example, by short duration of operation and direct access to the fracture in the deltoid-splitting group, might be a reason for higher early functional values [19]. But our meta-analysis showed it was not significant different in the two groups with random-effect model, even two RCTs [16,17] reported there was significant difference between. Whatever, for a long time fellow-up, it was no significant difference in the study. All studies included did not mention any difference of osteosynthesis between the two approached.

This study had many strengths; all of the included studies in this meta-analysis were RCT and prospective studies, which therefore overcomes the shortcomings of recall or selection bias in retrospective studies. The methodological index for nonrandomized studies (Newcastle – Ottawa Scale) was used to assess the quality of the included studies, which had minimized scores of 7, the score range of 7 to 9. However, there were still some limitations of present study, not all of them was randomized control trials, the sample size was not very large, and the duration of follow-up was less than 5 years. Therefore, we suggested further long-term, larger sample size, and randomized control trials to be conducted.

6. Conclusion

The prospective evidence suggested that DS approach for proximal humerus fractures had less humeral head necrosis and short operation time than DP approach. Both DS and DP approach had similar results in functional outcomes, total complication, VAS, and hospital stay.

Disclosure of interest

The authors declare that they have no competing interest.

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Contribution

H. C. and LY. C. designed the study and LZ. X. wrote this manuscript. LZ. X. and YY. Z. searched database and reviewed studies. H. C., LZ. X. and LY. C. collected and analyzed data. X. L. All of the authors have read and approved the final manuscript.

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