Cemented versus uncemented hemi-arthroplasty for femoral neck fractures in elderly patients

A systematic review and meta-analysis of randomized controlled trials

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Abstract

Aim: To compare the efficacy and safety of cemented and uncemented hemiarthroplasty in elderly patients with femoral neck fracture.

Materials and methods: We searched PubMed, EMBASE, and Cochrane Library databases for published randomized clinical trials comparing cemented hemiarthroplasty with uncemented hemiarthroplasty in elderly patients with a femoral neck fracture. The search was not limited to language, time, or other factors. The quality of each study was assessed using the revised Jadad scale. Two researchers independently extracted data from all selected studies, including the following base line data: study period, fracture stage, number of patients, male female ratio, average age, and per-protocol (PP) or intent-to-treat (ITT), and the interest outcomes: the mortality at 12 months, operative time, hospital stay, common complications, prosthetic-related complications, blood loss and Harris Hip Score (HHS). Fixed-effects or random-effects models with mean differences and odds ratios were used to pool the continuous and dichotomous variables to determine heterogeneity of the included studies.

Results: A total of 8 studies involving 1577 hips (782 uncemented and 795 cemented) were included in this meta-analysis. The meta-analysis is indicated that the operation time of cemented hemiarthroplasty was longer than uncemented hemiarthroplasty and there was statistical significance between two groups (OR = −7.30, 95%CI, −13.13, −1.46; P = .01). However, there was no significant difference between the two methods of fixation in mortality at 12 months (OR = 1.22, 95%CI, 0.94–1.59; P = .14), hospital stay (OR = 0.26, 95%CI, −0.41, 0.93; P = .44), blood loss (OR = −17.94, 95%CI, −65.83, 29.95; P = .46), and HHS score. There were significant differences in the common complications of pulmonary embolism between the two groups, but there were no differences in the other five common complications. The results showed that uncemented hemiarthroplasty could reduce the incidence of pulmonary embolism after operation. Moreover, the outcomes of prosthetic-related complications showed that there were significant differences between the two groups in periprosthetic fracture (OR = 8.32, 95%CI, 3.85–17.98; P < .00001) and prosthetic subsidence and loosening (OR = 5.33, 95%CI, 2.18–13.00; P = .0002).

Conclusions: Our study shows that uncemented prosthesis can shorten the operation time and reduce the incidence of pulmonary embolism, but it does not reduce mortality, blood loss, and hospital stay. Most importantly, the incidence of prosthetic-related complications was higher in uncemented patients.

Abbreviations: BCIS = Bone Cement Implantation Syndrome, CI = confidence intervals, HHS = Harris Hip Score, ITT = intent-to-treat, OR = odds ratio, PP = per-protocol, PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses, RCT = randomized controlled trials.

Keywords: cemented, femoral neck fractures, hemiarthroplasty, uncemented

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1. Introduction

Displaced fractures of the femoral neck in elderly patients is a common injury which can lead to high postoperative morbidity and mortality, typically as a consequence of trauma and osteoporosis.[1] Hemiarthroplasty is the standard treatment for these unstable fractures,[2,3] and mostly contributes to early ambulation and good functional recovery. Hemiarthroplasty can be divided into two different types: cemented and uncemented hemiarthroplasty. However, debate still exists regarding whether cemented or uncemented implant fixation is optimal in this surgery, especially for displaced femoral neck fractures is still uncertain.

Many studies have suggested that cemented hemiarthroplasty results in less implant-related complications, and provides better functional outcomes.[4–7] However, hemiarthroplasty with bone cement may lead to cardiovascular diseases such as cardiac arrhythmias and cardio-respiratory collapse.[8,9] Compared with cement prostheses, uncemented prostheses prevent the above infaust side effects and decrease blood loss and operation time.[10–12] However, the incidence of implant-related complications may be higher in uncemented group. Interestingly, some results published by Sophie et al in 2017 were different from those from majority of previous experiments.[13] In their experiment, the time of uncemented hemiarthroplasty was longer than that of cemented hemiarthroplasty, and the amount of blood loss was lower in cemented hemiarthroplasty. The aim of this updated meta-analysis was to comprehensively analyze literature on this topic to resolve such contradictions.

To compare the outcome of cemented and uncemented hemiarthroplasty in the treatment of displaced fractures of the femoral neck in elderly patients based on mortality at 12 months, operation time, hospital stay, blood loss, HHS score, and postoperative complications.

2. Methods

This study was designed according to PRISMA list[14] and registered on PROSPERO website (CRD42019120758).

2.1. Literature search strategies

Two reviewers independently conducted a comprehensive search of all literatures comparing cemented with uncemented hemiarthroplasty through online databases PUBMED, EMBASE, and Cochrane Library up to December 2018. The search medical subject headings (MeSH) terms were femoral neck fractures, (arthroplasty, replacement) and bone cements. The search was not limited to language of publication, time or any other parameter. A hand-search was also performed to identify additional relevant trials, reviews, related articles by screening the reference lists of all the selected articles.

2.2. Inclusion criteria and exclusion criteria

Inclusion criteria:

1. elderly patients over 70 years old with a displaced femoral neck fracture;
2. cemented and uncemented hemiarthroplasty;
3. the study compared the outcome of cemented and uncemented hemiarthroplasty and reported at least one of the following outcomes: mortality at 12 months, operative time, hospital stay, blood loss and HHS score;
4. the randomized controlled trials (RCT).

Exclusion criteria:

1. basic research on animals or cadavers;
2. studies in which it was impossible to extract or convert valid data;
3. case report and retrospective studies;
4. systematic review and meta-analysis;
5. conference papers without full text.

Two authors independently screened the titles and abstracts according to the inclusion criteria and excluded the articles that did not meet the requirements. Subsequently, the full text was read to determine whether the study could be included in the final analysis. Any discrepancies during this period were resolved through discussion with a third reviewer until a consensus was reached.

According to the search strategy, we retrieved 213 articles from PubMed, Embase, Cochrane library, and 14 articles by hand searching. Initially, 29 duplicate records were excluded and later 154 inappropriate records were excluded based on titles and abstracts. After full-text reading, ten articles met the inclusion criteria and all of them were included in qualitative synthesis, but two of them were published repeatedly, so they were excluded from our meta-analysis.[14] If an author had more than one eligible publication, the original article was used (because the data is more accurate). The remaining 8 articles were included in this meta-analysis.[13,15–21] The details of the search and exclusion process are shown in the flowchart (Fig. 1).

All analyses were based on previous published studies; thus, no ethical approval and patient consent were required.

2.3. Data extraction

Two reviewers extracted relevant data independently from the included RCTs.

The following data was retrieved; the mortality at 12 months, operative time, hospital stay, blood loss, and HHS score. Data on common complications was recorded as secondary outcomes. In addition, the following base-line data were obtained: study period, fracture stage, number of patients, male-female ratio, average age, and PP or ITT.

Any disagreements regarding the inclusion or exclusion of a study were resolved through discussions. In cases where more data was required for meta-analysis, an e-mail was sent to the original author for clarification.

A publication bias assessment using forest plots was intended to be conducted if no <10 studies were included.

2.4. Outcome measures

In hemiarthroplasty, the risk of mortality is often a challenge to clinicians. Therefore, we analyzed the mortality rate at 12th month in the two groups of patients among the studies. Concurrently, we collected the data on the extend of bleeding and the operation time to assess the impact of cemented and uncemented prostheses in hemiarthroplasty. To evaluate the hip function recovery after surgery in both groups, we collected hospital stay data and HHS scores. Occurrence of complications in hemiarthroplasty, such as cardiovascular diseases, deep vein thrombosis, pneumonia, and among others limits the efficacy of this procedure. These complications affect the recovery of hip function post-operation thus affecting the patient's mortality and hospitalization time. Other major local complications related to
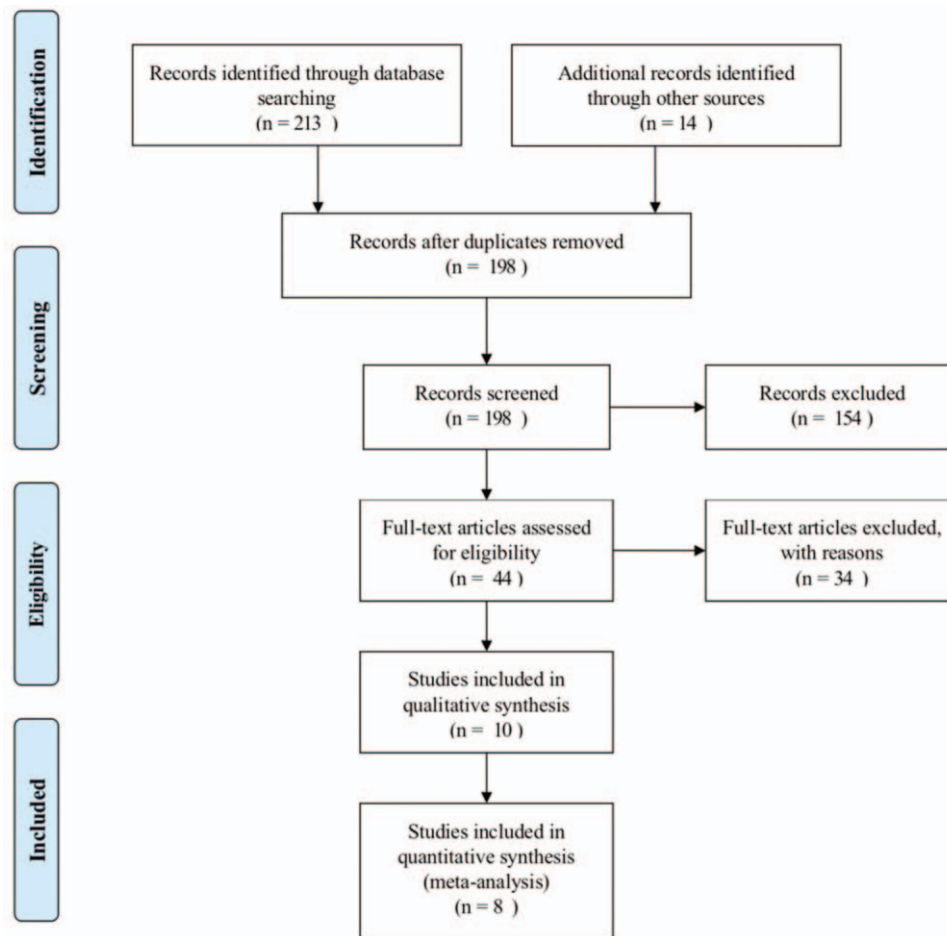
Figure 1. Flowchart of selection of studies.

the prosthetic include, periprosthetic fracture and prosthetic loosening and subsidence all of which directly increase the rate of reoperation after surgery. Consequently, data on common complications and the major local complications were included in the meta-analysis.

2.5. Quality assessment

Two reviewers independently assessed the quality of each study using the revised Jadad scale.[22] This latest scale describes how to obtain random sequences (0–2 points), how to randomize concealment (0–2 points), blind method (0–2 points), and the number and reasons for withdrawals or dropouts (0–1 points). The total score is 7 points, whereby 0 to 3 points are considered low quality and 4 to 7 points are considered as high quality.

2.6. Statistical analysis

Dichotomous outcomes were pooled and reported as relative risks, while continuous outcomes were pooled and reported as standardized mean differences. Both outcomes were calculated at 95% confidence intervals. Statistical heterogeneity among studies was evaluated by χ^2 test and I^2 test. Sensitivity analyses were also performed to evaluate the stability of the results. There was no statistical heterogeneity if a P value $>.1$ and $I^2 < 50\%$. In that case, the fixed-effects model was used to perform the meta-analysis.

Otherwise, we adopted the random-effects model. Furthermore, subgroup analysis or sensitivity analysis were performed. All statistical analyses were carried out with the Review Manager Software (RevMan 5.3).

3. Results

All the included studies in the meta-analysis were published between 1991 and 2017 in English. A total of 1577 hips were analyzed from the 8 studies: 782 hips in the uncemented hemiarthroplasty group and 795 hips in the cemented hemi-arthroplasty group. The characteristics of these studies and baseline data are displayed in Table 1.

All eight studies were assessed using the revised Jadad scale. After the evaluation, one low-quality study[21] and seven high-quality studies were identified. Two trials used computer-generated numbers,[16,18] but other studies did not describe the method of random allocation. Six trials adopted randomly numbered envelopes to hide randomly.[13,16–18,20,21] One trial showed only the scheme of random allocation,[19] and the other was inappropriate.[15] One trial had 3 points (with a low quality) while others trials had 4 to 7 points (with a high quality).

3.1. Mortality

Six studies reported the mortality at 12 months with a total of 1200 patients (609 cemented and 591 uncemented).[13,15,16,18–20]

Main characteristics of all eligible studies included in the analysis.

Studies	Period	Design	Bipolar/unipolar	Stage	Hips (UCH/CN)	Mean age (y) (UCH/CH)	Female (n) (UCH/CH)	Follow-up (mon)	ITT/PP	Outcome
Dinko 2013[15]	2007.1–2010.12	RCT		III, IV	41/38	82.04/82.9	41/38	12	ITT	Mortality at 12 month, operative time, hospital day, HHS score
Ellen2014[16]	2004.9–2006.8	RCT	Bipolar		108/112	83.0/83.4	80/87	3,12,60	PP	Mortality at 12 month, operative time, hospital day, blood loss, HHS score
Emery 1991[17]		RCT	Bipolar		26/27	79.6/78.0	22/24	17	ITT	Operative time, hospital day, blood loss
Fraser 2012[18]	2006.5–2008.11	RCT	Unipolar	III, IV	80/80	85.1/85.3	53/57	6,12,24	ITT	Mortality at 12 month, operative time, hospital day, blood loss
Joseph 2012[19]	2005.3–2008.5	RCT	Unipolar		64/66	82.8/81.8	48/52	1,2,12	ITT	Mortality at 12 month, operative time, blood loss
Parker 2010[20]	2001.3–2006.11	RCT			200/200	83.0/83.0	147/161	24–60	ITT	Mortality at 12 month, operative time, hospital day
Sophie 2017[13]	2008.8–2012.6	RCT		III, IV	91/110	84.0/83.0	61/82	12	ITT	Mortality at 12 month, operative time, hospital day, blood loss
Talsnes 2013[21]	2005–2010	RCT	Bipolar	III, IV	172/162	84.0/84.3	135/117	12	ITT	Operative time, blood loss

ITT = intent-to-treat, PP = per-protocol, RCT = randomized controlled trials.

The results showed that there was no heterogeneity ($P = .68$, $I^2 = 0\%$), therefore, the fixed-effect model was used. The analysis indicated that the mortality rate was not significantly different between uncemented and cemented hemiarthroplasty groups (OR = 1.22, 95%CI, 0.94–1.59; $P = .14$) (Fig. 2).

3.2. Operation time

The eight trials reported operation time for 1587 patients (798 cemented and 789 uncemented). The operation time here is defined as the time from skin to skin. Due to the high heterogeneity observed ($P < .00001$, $I^2 = 97\%$), the random-effects model was adopted to pool the data. The operation time of cemented hemiarthroplasty was longer than that of uncemented hemiarthroplasty. The results showed that there was a significant difference between two groups (OR = −7.30, 95%CI, −13.13, −1.46; $P = .01$) (Fig. 3).

To determine the source of heterogeneity, a sensitivity analysis was performed excluding this trial. It was found that the pooled results displayed heterogeneity as evidenced by the decrease in I^2 from 97% to 51% and there was no difference in operation time between the two groups (OR = −13.00, 95% CI, −11.68 to −6.69; $P < .00001$).

3.3. Hospital stay

Hospital stay was reported in six studies for 1123 patients (570 cemented and 553 uncemented).[13,15–18,20] The analysis showed that there was no heterogeneity ($P = .52$, $I^2 = 0\%$), thus we choose the fixed-effect model for data analysis. The results indicated that there was no significant difference between the two groups in hospital stay after pooling the data (OR = 0.26, 95%CI, −0.41, 0.93; $P = .44$) (Fig. 4).

3.4. Blood loss

Six trials described the outcome of blood loss in 1080 patients (532 cemented and 548 uncemented).[13,16–19,21] Owing to the
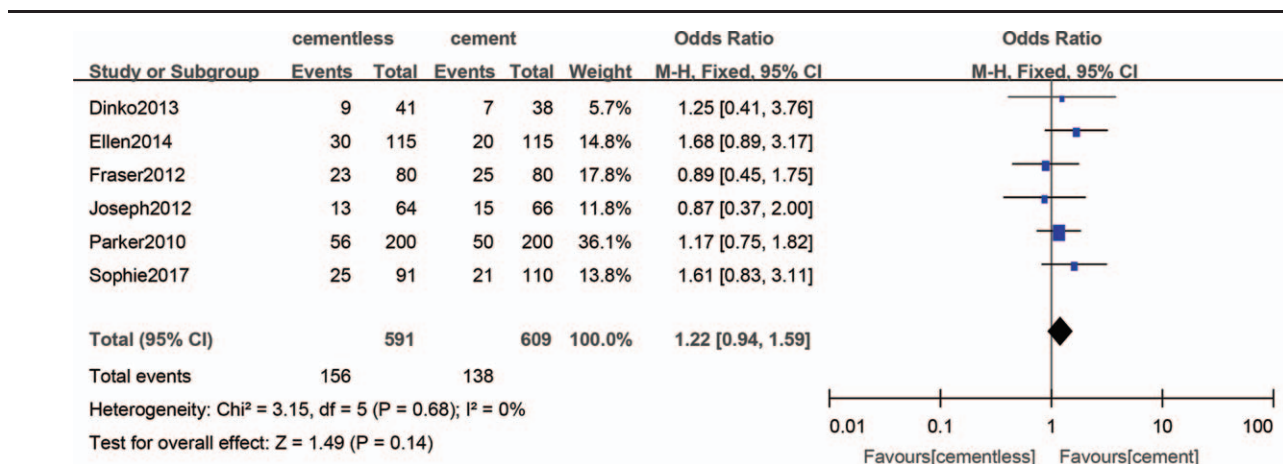

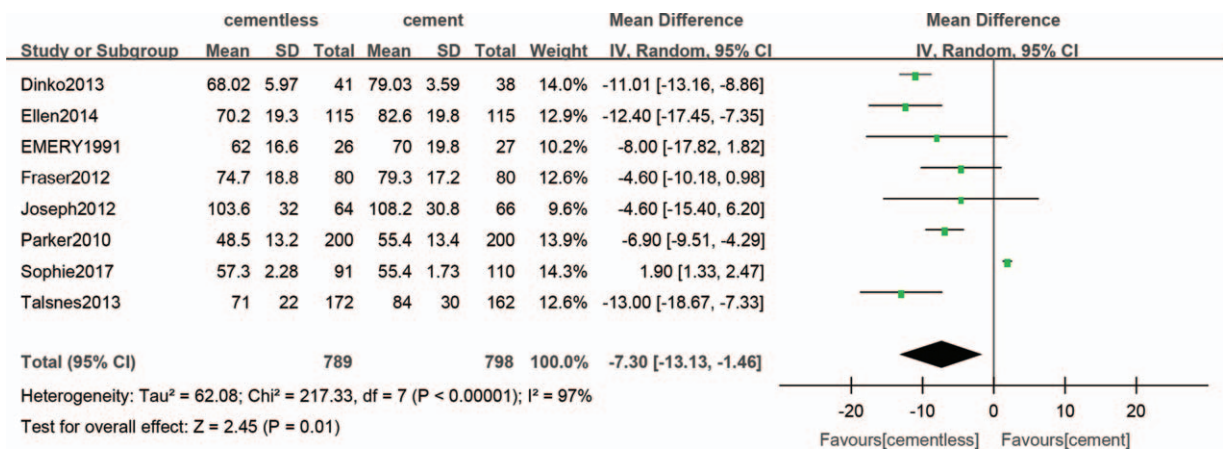**Figure 2.** Forest plot for the mortality rate at 12 months.

	cementless			cement				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	
Dinko2013	68.02	5.97	41	79.03	3.59	38	14.0%	-11.01 [-13.16, -8.86]	
Ellen2014	70.2	19.3	115	82.6	19.8	115	12.9%	-12.40 [-17.45, -7.35]	
EMERY1991	62	16.6	26	70	19.8	27	10.2%	-8.00 [-17.82, 1.82]	
Fraser2012	74.7	18.8	80	79.3	17.2	80	12.6%	-4.60 [-10.18, 0.98]	
Joseph2012	103.6	32	64	108.2	30.8	66	9.6%	-4.60 [-15.40, 6.20]	
Parker2010	48.5	13.2	200	55.4	13.4	200	13.9%	-6.90 [-9.51, -4.29]	
Sophie2017	57.3	2.28	91	55.4	1.73	110	14.3%	1.90 [1.33, 2.47]	
Talsnes2013	71	22	172	84	30	162	12.6%	-13.00 [-18.67, -7.33]	
Total (95% CI)			789			798	100.0%	-7.30 [-13.13, -1.46]	

Heterogeneity: Tau² = 62.08; Chi² = 217.33, df = 7 (P < 0.00001); I² = 97%
Test for overall effect: Z = 2.45 (P = 0.01)

Figure 3. Forest plot for the operation time.

	cementless			cement				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI	
Dinko2013	8.02	1.72	41	7.82	1.85	38	71.6%	0.20 [-0.59, 0.99]	
Ellen2014	8.4	9.02	115	7.8	4.11	115	13.6%	0.60 [-1.21, 2.41]	
EMERY1991	19.5	8.4	26	21.8	11.7	27	1.5%	-2.30 [-7.77, 3.17]	
Fraser2012	26.5	14.26	80	27.2	14.6	80	2.2%	-0.70 [-5.17, 3.77]	
Parker2010	24.7	25.8	200	20.3	22.3	200	2.0%	4.40 [-0.33, 9.13]	
Sophie2017	11	7.7	91	11	8.3	110	9.1%	0.00 [-2.22, 2.22]	
Total (95% CI)			553			570	100.0%	0.26 [-0.41, 0.93]	

Heterogeneity: Chi² = 4.18, df = 5 (P = 0.52); I² = 0%
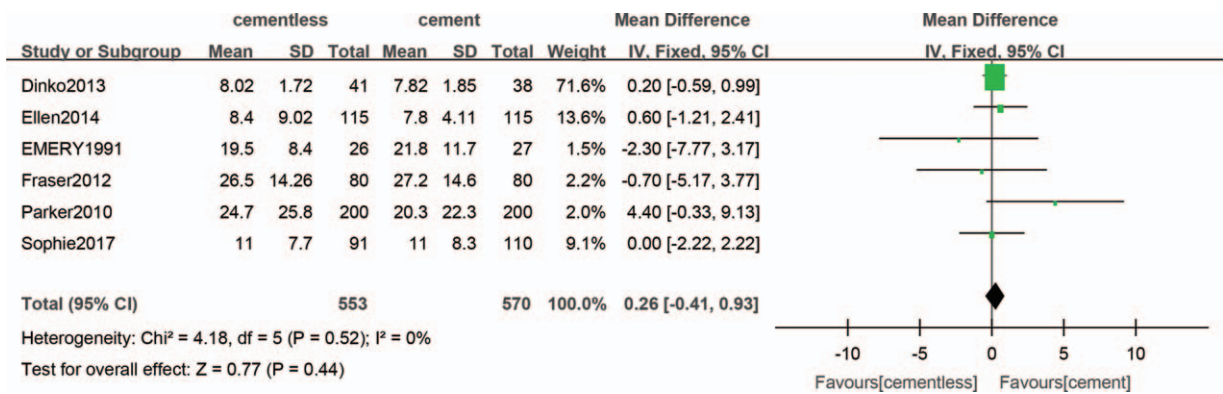Test for overall effect: Z = 0.77 (P = 0.44)

Figure 4. Forest plot for the hospital stay.

high heterogeneity ($P=.002$, $I^2=74\%$), random-effects model was adopted to pool the data. Results showed that there was no significant difference in blood loss between two groups ($OR=-17.94$, 95%CI, -65.83, 29.95; $P=.46$) (Fig. 5).

To identify possible sources of heterogeneity, we analyzed the selected trials. We found that the study by Sophie et al was the source of high heterogeneity. In their study, data were estimated by doctors based on experience and surgical conditions, but not by actual measurements.[13] However, the heterogeneity between the two groups persisted even after omission of Sophie et al article in the sensitivity analysis ($I^2=57\%$).

3.5. HHS score

Two studies provided information on HHS score in 309 patients (153 cemented and 156 uncemented).[15,16] The data indicated a high heterogeneity ($P=.03$, $I^2=78\%$), and therefore the random-effect model was applied. There was no significant difference in

	cementless			cement				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	
Ellen2014	521	265	115	598	278	115	15.4%	-77.00 [-147.20, -6.80]	
EMERY1991	276	133	26	325	131	27	15.2%	-49.00 [-120.10, 22.10]	
Fraser2012	251	156.8	80	254	130.8	80	19.1%	-3.00 [-47.74, 41.74]	
Joseph2012	279	177	64	257	158	66	17.2%	22.00 [-35.74, 79.74]	
Sophie2017	288	213	91	220	143	82	17.8%	68.00 [14.40, 121.60]	
Talsnes2013	410	219	172	502	413	162	15.2%	-92.00 [-163.52, -20.48]	
Total (95% CI)			548			532	100.0%	-17.94 [-65.83, 29.95]	

Heterogeneity: Tau² = 2599.15; Chi² = 19.09, df = 5 (P = 0.002); I² = 74%
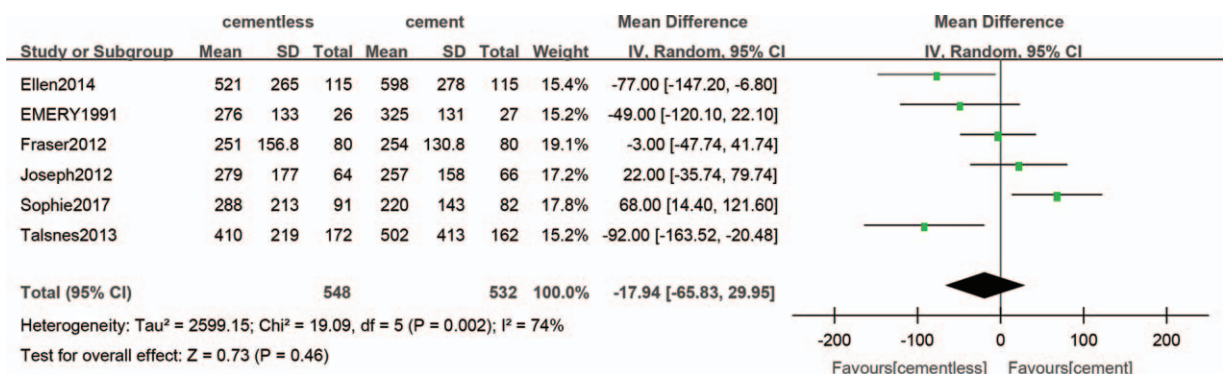Test for overall effect: Z = 0.73 (P = 0.46)

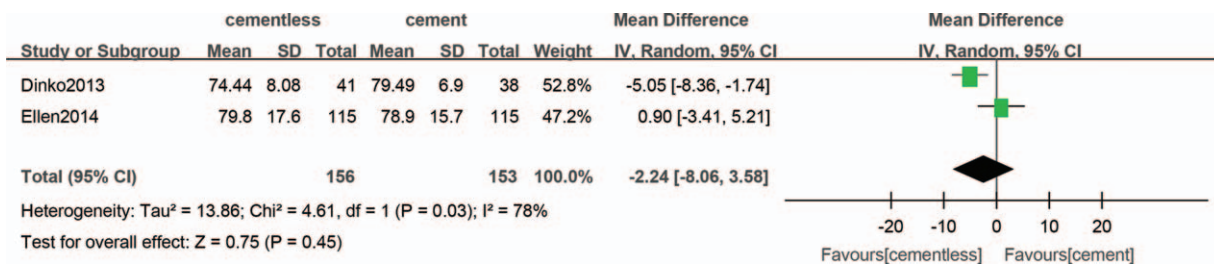**Figure 5.** Forest plot for the blood loss.

Figure 6. Forest plot for the HHS score.

HHS scores between the two groups (OR = −2.24, 95%CI, −8.06, 3.58; P = .45) (Fig. 6).

3.6. Complication

Occurrence of complications was analyzed through subgroup analyses as follows:

Three trials reported reoperation in 520 patients (261 cemented and 259 uncemented).[16,18,19] The data indicated that there was no heterogeneity (P = .61, I^2 = 0%), and no significant difference in reoperation between uncemented and cemented hemiarthroplasty group (OR = 1.52, 95%CI, 0.68–3.41; P = .31). (Fig. 7)

Three studies mentioned occurrence of pulmonary embolism in 626 patients (309 cemented and 317 uncemented).[13,17,20] The data indicated that there was no heterogeneity (P = .98, I^2 = 0%), and there was significant difference in pulmonary embolism between the two groups (OR = 0.16, 95%CI, 0.04–0.75; P = .02).

Four trials reported angiocardiopathy for 863 patients (428 cemented and 435 uncemented).[13,18–20] The pooled analysis showed no heterogeneity among the studies and no significant difference in angiocardiopathy between two groups (OR = 1.02, 95%CI, 0.55–1.92; P = .94; I^2 = 0%, P = .62).

Dislocation was measured in three trials in 733 patients (362 cemented and 371 uncemented).[13,18,20] There was no heterogeneity (P = .42, I^2 = 0%), and no significant difference was observed between the two groups in terms of dislocation (OR = 0.81, 95%CI, 0.28–2.37; P = .70) according to the pooled analysis.

Data on deep venous thrombosis was reported in two studies for 573 patients (282 cemented and 291 uncemented).[13,20] The pooled analysis found no heterogeneity and there was no significant difference between the two groups (OR = 0.69, 95% CI, 0.14–3.50; P = .65, I^2 = 0%, P = .53).

Three studies reported pneumonia in 703 patients (348 cemented and 355 uncemented),[13,19,20] and the analysis indicated a high heterogeneity (P = .07, I^2 = 62%) with no significant difference between the two groups (OR = 1.46, 95% CI, 0.75–2.85; P = .27).

Five included articles reported periprosthetic fractures in 1093 patients (543 cemented and 550 uncemented).[13,16,18–20] The results showed that there were significant differences between the two groups (OR = 8.32, 95%CI, 3.85–17.98; P < .00001). The uncemented group had a higher risk of periprosthetic fracture than the cemented group. Moreover, there was no heterogeneity between the two groups (P = .22, I^2 = 30%).

Finally, two articles mentioned prosthesis loosening and subsidence occurring in 333 patients (162 cemented and 171 uncemented).[13,18] The results showed that there was a significant difference between cemented hemiarthroplasty group and cementless hemiarthroplasty group (OR = 5.33, 95%CI, 2.18–13.00; P = .0002), whereby the uncemented prosthesis had more loosening and subsidence than the cemented prosthesis. The results revealed a high level of heterogeneity (P = .04, I^2 = 76%).

4. Discussion

Femoral neck fracture is a common medical condition affecting the elderly. Given the prolongation of human life span, the incidence of femoral neck fracture has been on the rise. As the ageing population increases, this condition is expected to negatively affect the social welfare of the elderly. So far, the treatment and outcome of femoral neck fracture are not sufficiently managed. Hemiarthroplasty is often used to treat femoral neck fracture due to its ability to improve hip function after operation. However, controversy exists in the application of two different prostheses, the cemented and uncemented prosthesis. Some researchers believe that cemented prosthesis is better than uncemented prosthesis in restoring postoperative function of the joint.[4,5,12,23–25] However, other studies have shown that there is no difference between cemented and uncemented prostheses in the outcome of hip function after surgery.[26–28] In fact some studies indicated that there is no difference in occurrence of post-operative complications between cemented and uncemented groups in hemiarthroplasty.[6] In terms of postoperative complications, Jameson et al found that the incidence of implant-related complications, including periprosthetic fractures and prosthetic loosening and subsidence, was higher in the uncemented group.[29] However, there was no difference in the occurrence of common complications between the two groups.[30] Similarly, our results showed that uncemented hemiarthroplasty does not reduce common complications after surgery, but increases prosthesis-related complications.

To provide a comprehensive and reliable conclusion, we performed this meta-analysis based on 8 eligible RCTs comparing cemented and uncemented hemiarthroplasty according to our pre-set inclusion and exclusion criteria.

Almost every RCT reported mortality data, but at different time-points, for example, during intraoperative period, postoperative 1 week, 1 month, 1 year, and 5 years. Majority of the studies reported the mortality rate at 12-month. Therefore, we analyzed the 12-month mortality data from six RCTs.

Although some researchers believe that bone cement has a higher mortality rate[7] or that uncemented procedure has a higher mortality rate,[31] our results indicate that there was no difference in mortality rate between the two groups at 12 months, which is consistent with previous reports.[11,12,27,32] This conclusion has been reported in other systematic reviews.[4,5,24]
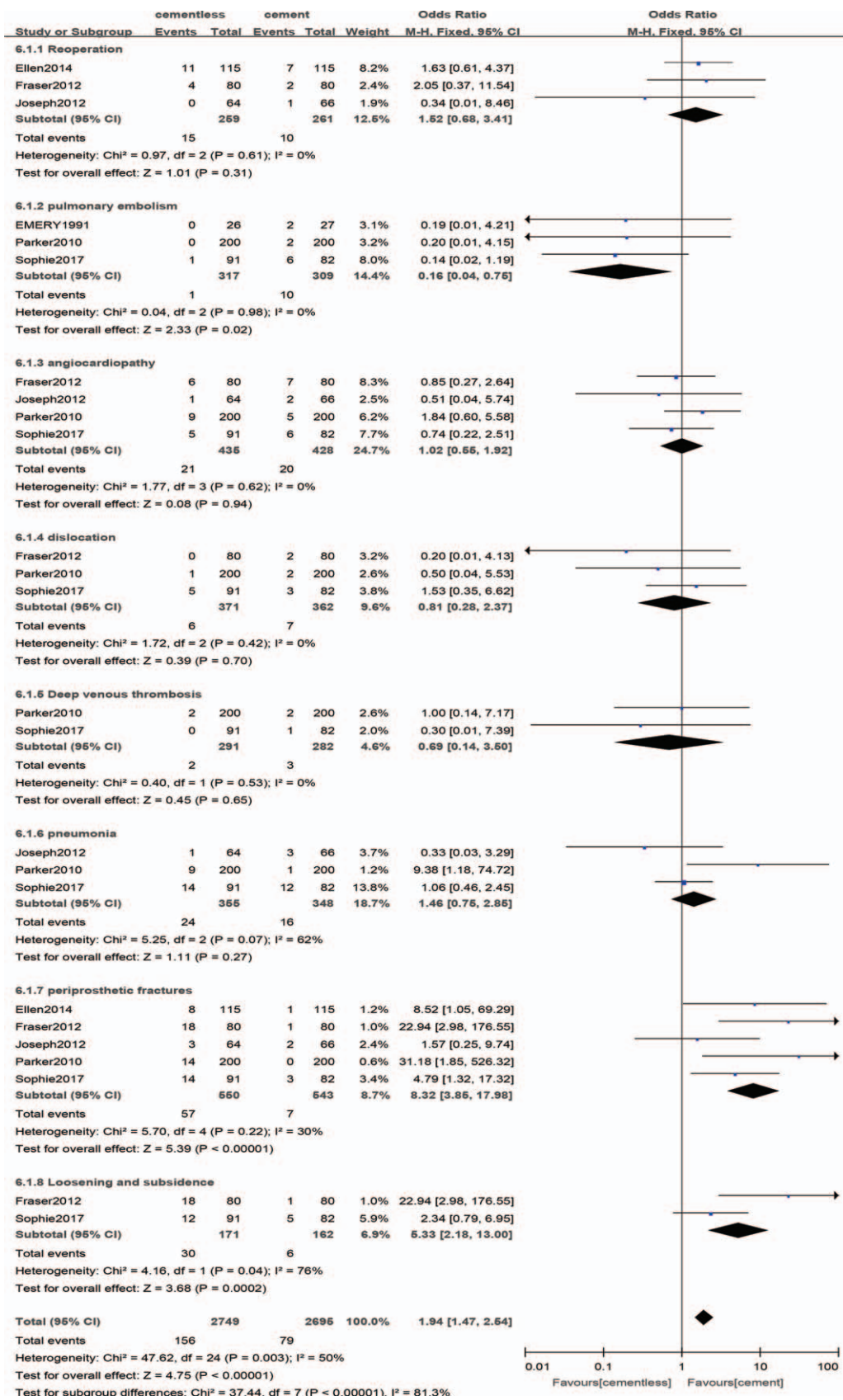
Study or Subgroup	cementless Events	Total	cement Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
6.1.1 Reoperation						
Ellen2014	11	115	7	115	8.2%	1.63 [0.61, 4.37]
Fraser2012	4	80	2	80	2.4%	2.05 [0.37, 11.54]
Joseph2012	0	64	1	66	1.9%	0.34 [0.01, 8.46]
Subtotal (95% CI)		259		261	12.5%	1.52 [0.68, 3.41]
Total events	15		10			
Heterogeneity: Chi² = 0.97, df = 2 (P = 0.61); I² = 0%						
Test for overall effect: Z = 1.01 (P = 0.31)						
6.1.2 pulmonary embolism						
EMERY1991	0	26	2	27	3.1%	0.19 [0.01, 4.21]
Parker2010	0	200	2	200	3.2%	0.20 [0.01, 4.15]
Sophie2017	1	91	6	82	8.0%	0.14 [0.02, 1.19]
Subtotal (95% CI)		317		309	14.4%	0.16 [0.04, 0.75]
Total events	1		10			
Heterogeneity: Chi² = 0.04, df = 2 (P = 0.98); I² = 0%						
Test for overall effect: Z = 2.33 (P = 0.02)						
6.1.3 angiocardiopathy						
Fraser2012	6	80	7	80	8.3%	0.85 [0.27, 2.64]
Joseph2012	1	64	2	66	2.5%	0.51 [0.04, 5.74]
Parker2010	9	200	5	200	6.2%	1.84 [0.60, 5.58]
Sophie2017	5	91	6	82	7.7%	0.74 [0.22, 2.51]
Subtotal (95% CI)		435		428	24.7%	1.02 [0.55, 1.92]
Total events	21		20			
Heterogeneity: Chi² = 1.77, df = 3 (P = 0.62); I² = 0%						
Test for overall effect: Z = 0.08 (P = 0.94)						
6.1.4 dislocation						
Fraser2012	0	80	2	80	3.2%	0.20 [0.01, 4.13]
Parker2010	1	200	2	200	2.6%	0.50 [0.04, 5.53]
Sophie2017	5	91	3	82	3.8%	1.53 [0.35, 6.62]
Subtotal (95% CI)		371		362	9.6%	0.81 [0.28, 2.37]
Total events	6		7			
Heterogeneity: Chi² = 1.72, df = 2 (P = 0.42); I² = 0%						
Test for overall effect: Z = 0.39 (P = 0.70)						
6.1.5 Deep venous thrombosis						
Parker2010	2	200	2	200	2.6%	1.00 [0.14, 7.17]
Sophie2017	0	91	1	82	2.0%	0.30 [0.01, 7.39]
Subtotal (95% CI)		291		282	4.6%	0.69 [0.14, 3.50]
Total events	2		3			
Heterogeneity: Chi² = 0.40, df = 1 (P = 0.53); I² = 0%						
Test for overall effect: Z = 0.45 (P = 0.65)						
6.1.6 pneumonia						
Joseph2012	1	64	3	66	3.7%	0.33 [0.03, 3.29]
Parker2010	9	200	1	200	1.2%	9.38 [1.18, 74.72]
Sophie2017	14	91	12	82	13.8%	1.06 [0.46, 2.45]
Subtotal (95% CI)		355		348	18.7%	1.46 [0.75, 2.85]
Total events	24		16			
Heterogeneity: Chi² = 5.25, df = 2 (P = 0.07); I² = 62%						
Test for overall effect: Z = 1.11 (P = 0.27)						
6.1.7 periprosthetic fractures						
Ellen2014	8	115	1	115	1.2%	8.52 [1.05, 69.29]
Fraser2012	18	80	1	80	1.0%	22.94 [2.98, 176.55]
Joseph2012	3	64	2	66	2.4%	1.57 [0.25, 9.74]
Parker2010	14	200	0	200	0.6%	31.18 [1.85, 526.32]
Sophie2017	14	91	3	82	3.4%	4.79 [1.32, 17.32]
Subtotal (95% CI)		550		643	8.7%	8.32 [3.85, 17.98]
Total events	57		7			
Heterogeneity: Chi² = 5.70, df = 4 (P = 0.22); I² = 30%						
Test for overall effect: Z = 5.39 (P < 0.00001)						
6.1.8 Loosening and subsidence						
Fraser2012	18	80	1	80	1.0%	22.94 [2.98, 176.55]
Sophie2017	12	91	5	82	5.9%	2.34 [0.79, 6.95]
Subtotal (95% CI)		171		162	6.9%	5.33 [2.18, 13.00]
Total events	30		6			
Heterogeneity: Chi² = 4.16, df = 1 (P = 0.04); I² = 76%						
Test for overall effect: Z = 3.68 (P = 0.0002)						
Total (95% CI)		2749		2695	100.0%	1.94 [1.47, 2.64]
Total events	156		79			
Heterogeneity: Chi² = 47.62, df = 24 (P = 0.003); I² = 50%						
Test for overall effect: Z = 4.75 (P < 0.00001)						
Test for subgroup differences: Chi² = 37.44, df = 7 (P < 0.00001), I² = 81.3%						

Figure 7. Forest plot for the complications.

Some studies show that mortality is associated with intraoperative complications of pulmonary embolism, however, no patient died of pulmonary embolism.[18] Sophie et al stated that Bone Cement Implantation Syndrome (BCIS) is an important factor that increases the mortality rate in cemented hemiarthroplasty.[13] Others reduce mortality by excluding the weakest patients after surgery.[21] In our opinion, the patient's survival rate after surgery depends on the improvement of surgical techniques and the experience of doctors and careful monitoring during and after operation.

Based on the operation time, all the 8 studies reported the operation time for each patient and the pooled results showed that there was a high heterogeneity ($P < .00001$, $I^2 = 97\%$). It was found that the cemented hemiarthroplasty took longer time than uncemented hemiarthroplasty. We speculate that this could be due to the fact that hemiarthroplasty is a more established routine operation and hence many doctors are familiar with its manipulation. This result is consistent with previous studies.[12,23,24,27] It is generally believed that the operation time is longer in cemented hemiarthroplasty, due to the complexity of cement injection. However, uncemented hemiarthroplasty does not dispose the bone cement for a long time, but the operation should be more cautious, thus increasing the operation time.[19]

It is worth noting that one of these experiments is multicenter parallel-RCT, and the eight data in this article, including the operation time, were subjected to Bonferroni correction. In addition, the standard deviation of operation time in this trial was estimated by Cochrane transformation formula.[13] Therefore, we speculate that the factors mentioned in the above article may be the cause of the high heterogeneity in this analysis. The results showed that the operation time of uncemented bone was shorter than that of cemented bone. Due to the change in heterogeneity from severe to mild, we consider this as a source of the heterogeneity.

In elderly population, short operation time means that malignant events, such as high blood loss and complications may be reduced. Therefore, in this respect, the advantages of uncemented have a more important clinical significance.

Hemorrhage is a key complication of hemiarthroplasty, which may increase the incidence of cardiovascular diseases and mortality in the elderly individuals. Sophie et al found that cemented hemiarthroplasty was associated with high occurrence of hemorrhage,[13] but our meta-analysis indicates that there was no difference between the two groups, but a high heterogeneity after calculating the data of blood loss. This result is in agreement with the results of Veldman et al.[33]

Similar to a previous meta-analysis, there was no significant difference in the length of hospital stay between the two groups.[33] However, the conclusion from sensitivity analysis in another meta-analysis was unstable.[6] This instability may be due to the flow-up heterogeneity between the studies, two of which were published in the 1980s. In early studies, the hospital stay duration was influenced by inadequate equipment, inappropriate management of complications and poor post-operative recovery environment, which substantially affects the results of meta-analysis. In our meta-analysis, the studies included were performed between 1991 and 2017 and are not influenced by such factors and hence no heterogeneity. The duration of hospital time may also be affected by many factors, such as postoperative complications, functional recovery of hip joint, postoperative infection, among others. However, a less hospital stay may increase intension of care following discharge of patients after hemiarthroplasty, which may

increase the medical costs. Hence, more experimental evidence is required to support this preposition.

As for HHS score, in evaluation of postoperative functional outcome, only two of the included trials reported associated data. However, the results showed high heterogeneity. Unlike previously published work, our meta-analysis showed that there was no difference in functional recovery between the two groups. Moreover, we should be cautious about the HHS score. In the long-term follow-up, due to the death of patients or the change of treatment regimen or the loss of intraoperative follow-up, the final number of patients participating in this study is often quite different from the number of patients set in the initial experiment. Consequently, this may lead to a deviation in the final meta-analysis results. On the other hand, the methods used to assess functional outcomes are subjective and largely depend on the subjects' perception of recovery. Therefore, due to lack of involved trials, we are unable to make further analysis.

Beside, we collected and analyzed the data on six common complications, including reoperation rate, pulmonary embolism, angiocardiopathy, dislocation, deep venous thrombosis and pneumonia, and two local complications, periprosthetic fracture and prosthetic loosening and subsidence. Angiocardiopathy is the most dangerous complication of hemiarthroplasty and the main cause of increased mortality. Cemented implantation might increase the risk of transient hypotension and hypoxaemia, induce cerebrovascular complications and cardiovascular events which play an important role in mortality increase.[34–39] However, in a systematic review, the risk of cardiovascular and cerebrovascular diseases is equal,[4] and is the same in this case. This may be attributed to modern anesthesia techniques which can reduce the risk of these complications. From analysis of reoperation rate data, cardiovascular disease, dislocation, deep venous thrombosis and pneumonia, there was no difference between the two groups in these complications. However, uncemented hemiarthroplasty can reduce the risk of pulmonary embolism. Pulmonary embolism can lead to cardiogenic shock, acute heart failure and even sudden death after operation, not only increase the incidence of cardiovascular disease, but also increase the mortality rate. The choice of uncemented hemiarthroplasty to reduce the risk of pulmonary embolism is important for elderly patients with femoral neck fracture and provides a good choice of prostheses for doctors.

Periprosthetic fracture is a major local complication of hemiarthroplasty and directly leads to the risk of reoperation. Periprosthetic fractures include intraoperative femoral fractures and post-operative fractures (the duration of post-operative fractures ranges from 2 to 5 years depending on the follow-up time of each trial). Results of four studies showed that the uncemented group had a higher fracture rate. On one hand, slight bone or bone destruction may occur during intraoperative medullary preparation; in contrast, there is a gap between bone and prosthesis, which increases the risk of osteolysis and then increases the occurrence of prosthesis loosening.[40] However, in Joseph et al study, there was no difference in periprosthetic fracture event between the two groups. Therefore, we speculate that careful operation, intra-operative and improved surgical techniques have the potential to reduce the incidence of fracture.

After hemiarthroplasty, the risk factors of periprosthetic fracture of femur are mainly bone condition and surgical technique, and include age, sex, degree of osteoporosis, past surgical history and type of prosthesis. Therefore, in order to reduce periprosthetic fracture of femur, preventive measures

should be put in place, such as strict assessment of patients, selection of appropriate prostheses and surgical procedures before the first operation; avoiding bone damage and ensuring the correct placement of prosthesesduring operation; regular follow-up to achieve early detection and early treatment of prosthetic loosening after operation.

Generally, some investigators hold the view that uncemented hemiarthroplasty increase the risk of complications,[41–43] while others believed that cemented hemiarthroplasty is associated with many complications.[44] In our meta-analysis, the common complications were not different between the two groups, but the incidence of periprosthetic fractures and prosthetic loosening and subsidence, the major local complications were higher in the uncemented group.

4.1. Limitations

To increase the accuracy of results, strict inclusion and exclusion criteria were established leading to the inclusion of eight articles in this meta-analysis. In addition, one of the eligible articles was published in 1991 and involved only 27 patients in cemented group and 26 patients in uncemented group. Studies on small sample data may lead to unreliable results during meta-analysis. In our initial experimental design, the HHS score was chosen as the main reference for evaluating hip function after surgery, but only two articles mentioned this data.

4.2. Strengths

Our meta-analysis adopted a strict inclusion and exclusion criteria. We strictly excluded the Quasi-RCT and non-RCTs in order to ensure the credibility of outcomes. Investigators searched for trails that were not included in the database, and excluded inappropriate studies included in previous meta-analysis.

This study shows that uncemented prostheses can shorten the operation time but not the blood loss and duration of hospital stay. Although the incidence of pulmonary embolism was lower in the uncemented group, the mortality rate was not reduced. Most important, the incidence of prosthesis-related complications was higher in the uncemented group. Therefore, we suggest that uncemented prostheses should not be selected without appropriate considerations.

Author contributions

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