Cemented versus uncemented arthroplasty for the management of femoral neck fractures in the elderly

CURRENT STATUS: POSTED

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DOI: 10.21203/rs.2.23407/v1

SUBJECT AREAS
Orthopedics

KEYWORDS
Meta-analysis, cemented, arthroplasty, femoral neck fracture
Abstract
Background
Hemiarthroplasty and total hip arthroplasty (TKA) are commonly used to treat unstable femoral neck fractures in older patients. However, there is no consensus on the use of cement during hemiarthroplasty and TKA. Previous reviews on this subject included small number of studies and lacked evidence grading of outcomes. In this study, we aimed to compare the outcomes of cemented and uncemented arthroplasty for the treatment of femoral neck fractures in older patients.

Methods
A meta-analysis was conducted according to the guidelines of the Cochrane Collaboration using online databases (Pubmed, Cochrane Central Register of Controlled Trials, and Ovid). The quality of the included studies was assessed using the Cochrane Collaboration tool and Newcastle-Ottawa Scale. Prospective cohort studies and randomized controlled trials (RCT) of cemented arthroplasty versus uncemented arthroplasty for treatment of femoral neck fractures were analyzed using Review Manager (version 5.2) software.

Results
Sixteen studies were included in the meta-analysis. Cemented arthroplasty was found to be superior to uncemented arthroplasty with respect to reoperation rate, complications related to prosthesis, residual pain, and operation time. There were no significant between-group differences with respect to local and general complications, duration of hospital stay, hip function, and mortality.

Conclusion
Compared with cemented arthroplasty, uncemented arthroplasty was associated with a greater risk of complications related to prosthesis, reoperation rate, residual pain, and longer operation time. However, the results of this meta-analysis should be interpreted cautiously owing to some limitations. Further studies are required to provide more robust evidence.

Background
Femoral neck fractures account for approximately 57% of hip fractures and represent a rising problem in our aging society. The condition affects the quality of life and imposes a considerable social and
personal medical burden [1]. Hemiarthroplasty and TKA are commonly used for treatment of unstable femoral neck fractures in older patients [2]. However, there is no clear consensus on the use of cement during these procedures, and periprosthetic fracture, reoperation and mortality were reported differently for cemented and uncemented arthroplasty.

For cemented arthroplasty, polymethylmethacrylate cement is used to create a solid bone-implant interface. Some previous studies suggest that cemented arthroplasty may decrease the incidence of dislocation and loosening, facilitate early mobilization of hip movement, and improve postoperative hip function [3-5]. However, in other studies, use of cement was shown to increase intraoperative mortality or perioperative mortality due to cardiovascular disease; in these studies, cardiac output and stroke volume was decreased by 33% and 44%, respectively [6, 7].

In uncemented arthroplasty, initial implant rigidity is achieved via press-fit technique. The bond between the stem and femur is dependent on osseous integration [8]. However, the poor quality of bone in elderly patients may lead to many periprosthetic fractures [9].

Some randomized controlled trials (RCTs) and systematic reviews have also found differences between the outcomes of cemented and uncemented arthroplasty. In the study by Furnes et al, the incidence of reoperation after uncemented arthroplasty was higher than that after cemented arthroplasty [10]. In the study by Li et al, no significant difference was observed between cemented and uncemented arthroplasty with respect to mortality, reoperation rate, and fatal vascular disease; however, there was a higher risk of poor hip function and residual pain in the uncemented arthroplasty group [9]. Luo et al also observed a similar reoperation rate, mortality, and incidence of complications in the two groups [11]. In the study by Ning et al [12], residual pain was similar between the two groups; however, this finding was inconsistent with those of other two studies [13, 14]. Although many studies have compared the two treatments, these studies had some limitations. First, the sample size of the enrolled studies was small and many new published studies were not included. Second, some previous studies did not assess publication bias or evidence grading of outcomes. Third, some retrospective studies were included in the previous analysis, which provide low-quality evidence.
To provide more robust evidence for the treatment of femoral neck fractures in older patients (age > 65 years), we conducted an updated systematic review and meta-analysis to compare the effectiveness and safety of cemented and uncemented arthroplasty.

Methods
Eligibility criteria and literature search
We searched for relevant studies in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA) [15]. Studies that compared cemented versus uncemented arthroplasty for femoral neck fractures in older patients were searched in online databases including Pubmed, Cochrane Central Register of Controlled Trials, and Ovid. Studies published as of July 2019 were eligible for inclusion. The following medical subject heading (Mesh) were used to retrieve studies: “Femoral neck fractures,” “femoral fractures,” “hip,” “arthroplasty,” “replacement,” “cemented,” “uncemented,” “randomized controlled trial (RCT),” and “prospective.”

The inclusion criteria for this meta-analysis were: (1) patients (age > 65 years) diagnosed with femoral neck fracture; (2) intervention: patients treated by cemented hemiarthroplasty and THA; (3) comparison treatment: patients treated by uncemented hemiarthroplasty and THA; (4) outcomes: mortality, complications, reoperation, residual pain, hip function as assessed using hip harris score, operation time, and duration of hospital stay; 5) RCTs or prospective cohort trials were included; and 6) language of publication limited to English. The exclusion criteria were (1) duplicate publications, systematic reviews, case reports, and retrospective studies; (2) studies for whom full-text was not available; (3) presence of pathological fractures.

Outcomes of interest
The primary outcomes of this meta-analysis were incidence of mortality, complications, and reoperation. We divided complications into three categories: complications related to prosthesis, local complications, and general complications. Periprosthetic loosening, dislocation, and subsidence were included in complications related to prosthesis. Local complications included wound infection, hematoma, and heterotopic ossification. General complications included cerebrovascular and cardiovascular complications, urinary infection, bedsores, pneumonia, and renal failure. The secondary outcomes were residual pain, hip harris score for hip function, operation time, and duration
of hospital stay.

Data extraction and quality assessment
Data pertaining to study design, age, sex, type of prosthesis, follow-up, and outcomes were independently extracted by two researchers. The quality of the included studies was assessed using the Cochrane Collaboration recommendations for RCTs [16] and Newcastle-Ottawa Scale for prospective cohort studies [17]. The recommendations of Cochrane Collaboration include assessment of the following: random sequence generation (selection bias), allocation concealment (selection bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other sources of bias. The Newcastle-Ottawa Scale score for patient selection, comparability, and outcomes are shown in S1 Table. The total score is eight; the higher the score, the greater is the quality of cohort studies. In addition, the Gradeprofiler (version 3.6) was used to assess the grading for every meta-analysis in this review. According to the design, risk of bias, inconsistency, indirectness, and imprecision, the grading was divided into high, moderate, and low. The higher the grade, the greater is the quality.

Statistical analysis
Review Manager software (Version 5.2, The Nordic Cochrane Centre, The Cochrane Collaboration, 2012) was used for statistical analysis. Mean differences (MD) and 95% confidence intervals (CI) were calculated for continuous outcomes, and relative risk (RR) and 95% CI were calculated for dichotomous outcomes. Fixed-effect models were used when the $I^2 < 50\%$ and random-effect models were used when heterogeneity existed ($I^2 > 50\%$). Sensitivity analysis was conducted when $I^2 > 50\%$. Publication bias was also conducted by Review Manager (version 5.2). A $p$ value $< 0.05$ was considered statistically significant.

Results
Characteristics and qualities of the studies included
A flow diagram of the study according to the PRISMA statement was shown in Fig. 1. 421 studies were obtained by Pubmed (n = 204), Cochrane Central Register of Controlled Trials (n = 71), Ovid (n = 144) and other additional studies (n = 2). After duplication and reading full-text, sixteen studies were enrolled in this review. Among the sixteen studies, twelve of them were RCT [13, 14, 18–27] and four
of them were prospective cohort studies [3, 28-30]. There were 2180 hips analyzed in the 16 studies: 1087 hips for cemented arthroplasty and 1093 hips for uncemented arthroplasty. The 16 studies were showed in English and the full-text available. The detailed characteristics of included studies were shown in Table 1. There was a low risk bias for the RCTs included. Eight studies had adequate random sequence regeneration: two computer regeneration [13, 18] and six envelope regeneration [14, 20-23, 27]. Eight studies mentioned allocation concealment [13, 14, 18, 20-23, 27]. Of the sixteen studies, eight studies used observed blinding [13, 14, 18, 19, 22, 23, 26, 27], ten studies reported complete outcome [13, 14, 18-23, 25, 27], and ten studies reported all outcome date without reporting bias [13, 14, 18-23, 25, 27]. For prospective cohorts, three studies received eight score points [3, 28, 30] and one study received seven score points [29]. The detailed were shown in Fig. 2 and Table 2.
| Included study | Type    | Mean age (year) (C/UC) | Treatment (C/UC) | Gender (Male/female) | Type of operation | Type of prosthesis (C/UC) | Follow-up (C/UC) | Outcome |
|----------------|---------|------------------------|------------------|----------------------|-------------------|--------------------------|------------------|---------|
| Emery 1991[20] | RCT     | 78.0/79.6              | 27/26            | 53(7/46)             | Hemiarthroplasty   | Thompson/Austin Moore    | 17-18m          | 3②3④⑥ |
| Santini 2005[25] | RCT     | 82.09/79.68           | 53/53            | 106(24/82)           | Hemiarthroplasty   | Bipolar endoprosthesis/Bipolar endoprosthesis | 12 m           | 1②3④ |
| Parker 2010[14] | RCT     | 83/83                  | 200/200          | 400(308/92)          | Hemiarthroplasty   | Thompson/Austin Moore    | 60 m            | 3②3④⑤⑥ |
| Taylor 2012[13] | RCT     | 85.3/85.1              | 80/80            | 160(50/110)          | Hemiarthroplasty   | Exeter/Alloclassic       | 24 m            | 1②3④⑤⑥ |
| Deangelis 2012[19] | RCT   | 82.8/81.8              | 64/61            | 130(30/100)          | Hemiarthroplasty   | LD/Fx/Beaded FullCoat    | 12 m            | 1③4⑤ |
| Sadr and Arden 1977[24] | RCT | 77.0/78.4              | 20/20            | 40(10/30)            | Hemiarthroplasty   | Thompson/Thompson        | 3-17m           | 3④⑤⑥ |
| Sonne-Holm 1982[26] | RCT | 76                     | 55/57            | 112(37/75)           | Hemiarthroplasty   | Austin Moore/Austin Moore | 12 m           | 3④⑤⑥ |
| Singh 2006[3]    | PC      | 84/83                  | 25/29            | 54(8/46)             | Hemiarthroplasty   | Thompson/Austin Moore    | 12 m            | 3④⑤ |
| Chammout 2017[18] | RCT | 72/73                  | 35/34            | 69(22/47)            | THA                | THA                      | 24 m            | 1④⑤⑦ |
| Gavaskar 2013[30]    | PC    | 84.2/84                | 31/31            | 62(32/30)            | THA                | Exeter/HA-coated         | 24-46 m         | 1②3④⑤⑦ |
| Inngul 2015[21]   | RCT     | 81.2/81.3              | 67/74            | 141(42/99)           | Hemiarthroplasty and THA | Exeter/ hydrxyapatite coated Bimetric bipolar/bipolar | 12 m           | 3④⑤⑦ |
| Khorami 2016[29]   | PC      | 79.0/71.7              | 22/29            | 51(19/32)            | Hemiarthroplasty   | Exeter/HA-coated         | 18-20m          | 4⑤ |
| Langslet 2014[22] | RCT     | 83.4/83                | 112/108          | 223(NA/NA)           | Hemiarthroplasty   | Spectron/HA-coated       | 60 m            | 3②③④⑤⑥⑦ |
| Talsnes 2013[27]   | RCT     | 84.0/84.3              | 162/172          | 334(85/249)          | Hemiarthroplasty   | Bipolar implants/Bipolar implants | 12 m           | 1③ |
| Prashanth 2017[28] | PC     | 70                     | 24/28            | 52(22/30)            | Hemiarthroplasty   | Müller Straight Stem/type DB-10 | 12 m           | 2③4⑦ |
| Sophie 2017[23]    | RCT     | 83/84                  | 110/91           | 201(58/143)          | Hemiarthroplasty   | Müller Straight Stem/type DB-10 | 12 m           | 2③4⑤⑥ |

C: cemented; UC: uncemented; PC: prospective cohort; ①operation time;②hospital stay;③mortality;④complication; ⑤reoperation rate;⑥residual pain;⑦hip function
Table 2
Newcastle-Ottawa Scale of prospective cohort studies

| Author group | Selection | Representativeness of the exposed cohort | Selection | Representativeness of the non-exposed cohort | Ascertainment of exposure | Outcome | Outcome was not present at start of study | Comparability of controls | Comparability of exposure | Adequacy of follow-up | Adequacy of follow-up |
|--------------|-----------|-----------------------------------------|-----------|---------------------------------------------|--------------------------|---------|-------------------------------------------|---------------------------|--------------------------|----------------------|----------------------|
| Singh 2006[3] | 1         | 1                                       | 1         | 1                                           | 1                        | 1       | 1                                         | 1                         | 1                         | 1                    | 1                    |
| Gavaskar 2013[30] | 1         | 1                                       | 1         | 1                                           | 1                        | 1       | 1                                         | 1                         | 1                         | 1                    | 1                    |
| Khorami 2016[29] | 1         | 1                                       | 1         | 1                                           | 1                        | 1       | 1                                         | -                         | 1                         |                      | 1                    |
| Prashanth 2017[28] | 1         | 1                                       | 1         | 1                                           | 1                        | 1       | 1                                         | 1                         | 1                         | 1                    | 1                    |

Mortality

Thirteen studies enrolling 1998 hips reported mortality (Fig. 3). With respect to mortality within three months after operation, no significant difference was observed between the cemented group (11.7%, 101/860) and the uncemented group (11.7%, 103/877) [RR 0.99, 95% confidence interval (CI) 0.77–1.28], P = 0.96] using the fixed-effect model (I² = 0%). Similarly, with respect to mortality at last follow-up, no significant difference was observed between the cemented group (36.2%, 362/1001) and the uncemented group (36.9%, 368/997) (RR 0.97, 95% CI 0.88–1.08, P = 0.63, I² = 0%).

Complications

Fifteen studies enrolling 1851 hips reported complications (Fig. 4). The event rate for complications related to prosthesis was 3.2% (24/755) in the cemented group and 12.4% (93/749) in the uncemented group; the between-group difference in this respect was statistically significant (RR 0.27, 95% CI 0.17–0.41, P < 0.00001, I² = 41%). However, no significant between-group difference was observed with respect to incidence of local complications (RR 0.97, 95% CI 0.73–1.29, P = 0.84) or general complications (RR 0.99, 95% CI 0.82–1.18, P = 0.88).

Reoperation rate

Eleven studies enrolling 1640 hips reported reoperation rate (Fig. 5A). The duration of follow-up in the ten studies ranged from 3 to 60 months. The reoperation rate was 3.2% (26 of 823) in the cemented group and 5.8% (47 of 817) in the uncemented group. The fixed-effect model has been used since there was no heterogeneity (I² = 0%). There was a significant difference between the cemented group
and the uncemented group (RR 0.57, 95% CI 0.37–0.90, \( P = 0.02 \)).

**Residual pain**

Seven studies enrolling 698 hips were analyzed for residual pain within two years after operation (Fig. 5B). The data showed that there was no significant difference between the cemented group and the uncemented group [RR 0.66, 95% CI (0.52–0.83, \( P = 0.0004 \)]. Owing to lack of significant heterogeneity (\( I^2 = 0\% \)), the fixed-effect model was used for meta-analysis.

**Hip function**

Five studies enrolling 387 hips assessed hip function using the HHS (Fig. 5C). Owing to significant heterogeneity among these studies (\( I^2 = 55\% \)), a random-effect model was used for meta-analysis. No significant between-group difference was observed with respect to hip function (RR -0.67, 95% CI -4.52–3.18, \( P = 0.73 \)). On sensitivity analysis, one study [22] was found to contribute to the heterogeneity (Fig S1A). After exclusion of this study, similar results were obtained for the two groups (\( P = 0.32 \)).

**Operation time**

Ten studies enrolling 1675 hips had reported the operation time (Fig. 6A). Owing to significant heterogeneity among these studies (\( I^2 = 99\% \)), the random-effect model was used for meta-analysis. The operation time in the uncemented group was significantly shorter than that in the cemented group [mean difference (MD) 11.70, 95% CI 0.42–22.98, \( P = 0.04 \)]. On sensitivity analysis, one study [30] was found to be a major contributor to heterogeneity (Fig S1B). After exclusion of this study, operation time in the uncemented group was still significantly lower but with lesser heterogeneity among the included studies (MD 8.01, 95% CI 6.18–9.85, \( P < 0.00001 \), \( I^2 = 39\% \)).

**Hospital stay**

Eight studies enrolling 1235 hips reported on the duration of hospital stay (Fig. 6B). No significant difference was observed between the cemented group and the uncemented group using the random-effect model (MD 0.36, 95% CI -1.16–1.87, \( P = 0.65 \), \( I^2 = 78\% \)). On sensitivity analysis, one study [30] was found to contribute to the heterogeneity (Fig. S1C). After exclusion of this study, no significant difference was observed between the two groups with no heterogeneity (MD -0.04, 95% CI -0.78–0.70,
P = 0.92, \( I^2 = 0\% \).

GRADE assessment and publication bias

A summary quality assessment using the GRADE system (Grading of Recommendations Assessment, Development and Evaluation) was conducted (Fig. 7). The quality was high for the outcomes of operation time, complications related to prosthesis, and residual pain. For the outcomes of reoperation rates, general complications, and mortality at last follow-up, the quality of evidence was moderate. There was low quality of evidence pertaining to the hospital stay, local complication, hip function, and mortality within 3 months. No obvious publication bias was detected for complications (Fig. 8).

Discussion

Arthroplasty is currently the gold standard for treatment of femoral neck fractures in older patients. It is known to help improve the quality of life of patients. However, there is no consensus on the use of cement during arthroplasty. In this study, we synthesized evidence from 16 studies that compared cemented with uncemented arthroplasty for treatment of femoral neck fractures in older patients. We found that cemented arthroplasty was superior to uncemented arthroplasty with regards to the reoperation rate, complications related to prosthesis, and residual pain; however, the former required longer operation time. There was no significant difference between the two procedures with respect to mortality, duration of hospital stay, hip function, or general and local complications.

Compared with previous systematic reviews [9, 11, 12, 31–34], our meta-analysis improved certain aspects and provided some new insights. First, a larger sample of studies (16 studies) was included in our analysis, which helped decrease the selection bias. Second, the need for reoperation is a key concern both for surgeons and patients; previous systematic reviews including one latest review [35] found no differences between the two treatments with respect to reoperation rate. However, after inclusion of larger number of studies with longer follow-up period, we found that cemented arthroplasty may significantly decrease the reoperation rate; this finding is different from those reported by Li et al [9] and Luo et al [11]. Third, we included only RCTs and prospective cohort studies, which yielded higher quality data. Fourth, we performed subgroup analysis and sensitivity
analysis and explored potential factors that may have affected our results. Fifth, half of the included studies had a follow-up period of more than two years, which provided more robust evidence with respect to reoperation rate, mortality, residual pain, and hip function. Lastly, each outcome was assessed using the GRADE system.

Based on analysis of reoperation data from eleven studies, uncemented arthroplasty was associated with a significantly higher reoperation rate (5.8%) as compared to cemented group (3.2%). The higher reoperation rate after uncemented arthroplasty may be attributable to loosening of the prosthesis, intraoperative fracture, or dislocation. This outcome was different from previous systematic reviews [9, 11, 36, 37] where researchers found no significant differences between the cemented and uncemented groups. The difference may be due to a larger sample size and longer follow-up period in our study.

We also observed a significant difference between the cemented and uncemented groups with respect to the incidence of complications. There was significant heterogeneity and subgroup analysis was conducted ($I^2 = 93.6\%). Complications related to prosthesis were less frequent in the cemented group, which is supported by previous studies [9]; this may explain the higher reoperation rate in the uncemented group. Local and general complications in the cemented group were also less frequent than those in the uncemented group, although the between-group difference was not statistically significant. These findings are consistent with those of previous studies [12, 30, 38].

Mortality is another key concern in patients with femoral neck fracture. Thirteen studies were analyzed and the rate of mortality was comparable in the two groups. Many studies support our findings [12, 27]. In the study by Talsnes et al, the hazard ratio was 0.77 with no significant difference in mortality after long-term follow-up ($p = 0.233$). However, a study conducted in 1994 showed that use of cement may increase the intraoperative mortality rate due to the increased risk of cardiovascular disease on insertion [39]. In our study, one patient developed heart failure [21] and three patients developed cardiac arrest or myocardial infarction and died within 72 hours after cemented arthroplasty [13, 40]. The age of patients and preexisting cardiopulmonary symptoms may also affect the mortality rate [41].
Residual pain and hip function are key determinants of the quality of life of patients. In our study, cemented arthroplasty was significantly associated with less postoperative pain and similar hip function compared to uncemented group. This finding is consistent with the results reported by Ning et al and Bagaric et al [12, 32]. In the study by Figved et al, residual pain in the cemented group was greater than that in the uncemented group, although the difference was not statistically significant. This difference may be attributable to the different materials (hydroxyapatite-coated) used in the study populations included in the respective reviews. For analysis of HHS, there was significant heterogeneity among the included studies (55%); based on the results of sensitivity analysis, exclusion of one study [22] from the meta-analysis eliminated the heterogeneity ($I^2 = 0\%$). On further review of the literature, we found that in the study by Langslet et al, the HHS was significantly different between the two groups only in the fifth year. However, less than half of the original study population was followed-up. The heterogeneity may be attributable to the large number of patients who were lost to follow-up.

Our study demonstrated that cemented arthroplasty increases the operation time and this could be related to the additional procedures for cement insertion, which is consistent with many previous studies [18, 27, 29, 38]. With respect to the duration of hospital stay, our study found no significant difference between cemented and uncemented arthroplasty, which is consistent with Ning et al [12]. There was significant heterogeneity among the studies included in the meta-analysis of operation time and duration of hospital stay. Among these studies, data from the study by Gavaskar et al [30] was very concentrated with a very small standard deviation. Based on the results of sensitivity analysis, exclusion of the study by Gavaskar et al [30] reduced the heterogeneity among the remaining studies. Thus our results were credible.

Several limitations of our study should be considered while interpreting the results. First, some unpublished studies and non-English language studies were not included in our study, which could lead to bias. Second, information pertaining to random sequence generation and allocation concealment was not available for many of the included studies, which may lead to misjudgment of the quality. Third, the included studies involved the use of many different types of prosthesis; this
may have introduced an element of bias. Further analysis is required to provide stronger evidence for clinical treatment.

In our meta-analysis, we used the GRADE system to assess the evidence grading of the outcomes. The quality of evidence pertaining to the outcomes of reoperation rate, operation time, complications related to prosthesis, general complications, mortality, and residual pain was high or moderate. However, the evidence grading for hospital stay and local complications was low due to the following reasons. First, four of the included studies [3, 28–30] were prospective cohort studies and not RCTs. Second, the 95% confidence intervals around relative effects were very wide (range, 0.73–1.29) or there was considerable heterogeneity.

Conclusion
In summary, our study compared the outcomes of cemented and uncemented arthroplasty for femoral neck fractures in older patients. Our results suggest that cemented arthroplasty may help decrease reoperation rate and the incidence of complications related to prosthesis, and reduce residual pain. However, owing to the study limitations, there is a need for more high quality studies involving longer follow-up period to provide more definitive evidence.

Abbreviations
RCT; randomized controlled trial; PRISMA:Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Declarations

Ethics approval consent to participate
Not applicable

Consent for publication
Not applicable

Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.
Competing interests
The authors declare that they have no conflict of interest.

Funding
The work enrolled the design of study and collection of data, which was supported by International cooperation project of Sichuan provincial science and technology department (2019YFS0265) and postdoctoral fund of Sichuan university (2019SCU12034). The language polishing was supported by postdoctoral fund of west china hospital (2018HXBH076).

Authors’ contributions
XYT supervised the conception and design of the meta-analysis. LL participated in the meta analysis of each result and critically revised the manuscript. XDY critically revised the manuscript. JJ, LY and FX participated in the collection and analysis of the study data. All authors approved the final manuscript.

Acknowledgements
None.

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References
1. Gjertsen J-E, Engesæter LB, Furnes O, Havelin LI, Steindal K, Vinje T, Fevang JM: The Norwegian Hip Fracture Register: Experiences after the first 2 years and 15,576 reported operations. Acta Orthopaedica 2008, 79(5):583-593.
2. Bhandari M, Devereaux PJ, Tornetta P, Swiontkowski MF, Berry DJ, Haidukewych G, Schemitsch EH, Hanson B, Koval KJ, Dirschl DR: Operative management of displaced femoral neck fractures in elderly patients: An international survey. Journal of Bone and Joint Surgery, American Volume 2005, 87(9):2122-2130.

3. Singh GK, Deshmukh RG: Uncemented Austin-Moore and cemented Thompson unipolar hemiarthroplasty for displaced fracture neck of femur--comparison of complications and patient satisfaction. Injury-international Journal of The Care of The Injured 2006, 37(2):169-174.

4. Khan RJK, Macdowell A, Crossman P, Datta A, Jallali N, Arch BN, Keene GS: Cemented or uncemented hemiarthroplasty for displaced intracapsular femoral neck fractures. International Orthopaedics 2002, 26(4):229-232.

5. Lo W-H, Chen W-M, Huang C-K, Chen T-H, Chiu F-Y, Chen C-M: Bateman Bipolar Hemiarthroplasty for Displaced Intracapsular Femoral Neck Fractures Uncemented Versus Cemented. Clinical Orthopaedics and Related Research® 1994, 302:75-82.

6. Clark DI, Ahmed AB, Baxendale BR, Moran CG: Cardiac output during hemiarthroplasty of the hip: A PROSPECTIVE, CONTROLLED TRIAL OF CEMENTED AND UNCEMENTED PROSTHESES. Journal of Bone and Joint Surgery-british Volume 2001, 83(3):414-418.

7. Christie J, Burnett R, Potts HR, Pell ACH: Echocardiography of transatrial embolism during cemented and uncemented hemiarthroplasty of the hip. Journal of Bone and Joint Surgery-british Volume 1994, 76(3):409-412.

8. Sporer SM, Paprosky WG: Biologic fixation and bone ingrowth. The Orthopedic clinics of North America 2005, 36(1):105-111, vii.

9. Li T, Zhuang Q, Weng X, Zhou L, Bian Y: Cemented versus uncemented hemiarthroplasty for femoral neck fractures in elderly patients: a meta-analysis.
10. Gjertsen JE, Lie SA, Vinje T, Engesaeter LB, Hallan G, Matre K, Furnes O: More re-
operations after uncemented than cemented hemiarthroplasty used in the treatment
of displaced fractures of the femoral neck: an observational study of 11,116
hemiarthroplasties from a national register. The Journal of bone and joint surgery
British volume 2012, 94(8):1113-1119.

11. Luo X, He S, Li Z, Huang D: Systematic review of cemented versus uncemented
hemiarthroplasty for displaced femoral neck fractures in older patients. Archives of
Orthopaedic and Trauma Surgery 2012, 132(4):455-463.

12. Ning G, Li Y, Wu Q, Feng S, Li Y, Wu Q: Cemented versus uncemented
hemiarthroplasty for displaced femoral neck fractures: an updated meta-analysis.
European Journal of Orthopaedic Surgery and Traumatology 2014, 24(1):7-14.

13. Taylor F, Wright M, Zhu M: Hemiarthroplasty of the Hip with and without Cement: A
Randomized Clinical Trial. Journal of Bone and Joint Surgery, American Volume 2012,
94(7):577-583.

14. Parker MI, Pryor G, Gurusamy KS: Cemented versus uncemented hemiarthroplasty for
intracapsular hip fractures: A randomised controlled trial in 400 patients. Journal of
Bone and Joint Surgery-british Volume 2010, 92(1):116-122.

15. Moher D, Liberati A, Tetzlaff J, Altman DG: Preferred reporting items for systematic
reviews and meta-analyses: the PRISMA statement. International Journal of Surgery
2010, 8(5):336-341.

16. Furlan AD, Malmivaara A, Chou R, Maher CG, Deyo RA, Schoene ML, Bronfort G, Van
Tulder MW: 2015 Updated Method Guideline for Systematic Reviews in the Cochrane
Back and Neck Group. Spine 2015, 40(21):1660-1673.

17. Wells GA SB, O’Connell D, Peterson J, Welch V, Losos M: The Newcastle-Ottawa Scale
(NOS) for assessing the quality if nonrandomized studies in meta-analyses. Available from: URL: http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm. 2010.

18. Chammout G, Muren O, Laurencikas E, Boden H, Kelppettersson P, Sjoo H, Stark A, Skoldenberg O: More complications with uncemented than cemented femoral stems in total hip replacement for displaced femoral neck fractures in the elderly. Acta Orthopaedica 2017, 88(2):145-151.

19. Deangelis JP, Ademi A, Staff I, Lewis CG: Cemented versus uncemented hemiarthroplasty for displaced femoral neck fractures: a prospective randomized trial with early follow-up. Journal of Orthopaedic Trauma 2012, 26(3):135-140.

20. Emery RJH, Broughton NS, Desai K, Bulstrode CJK, Thomas TL: Bipolar hemiarthroplasty for subcapital fracture of the femoral neck. A prospective randomised trial of cemented Thompson and uncemented Moore stems. Journal of Bone and Joint Surgery-british Volume 1991, 73(2):322-324.

21. Inngul C, Blomfeldt R, Ponzer S, Enocson A: Cemented versus uncemented arthroplasty in patients with a displaced fracture of the femoral neck: a randomised controlled trial. Journal of Bone and Joint Surgery-british Volume 2015(11):1475-1480.

22. Langslet E, Frihagen F, Opland V, Madsen JE, Nordsletten L, Figved W: Cemented versus Uncemented Hemiarthroplasty for Displaced Femoral Neck Fractures: 5-year Followup of a Randomized Trial. Clinical Orthopaedics and Related Research 2014, 472(4):1291-1299.

23. Moerman S, Mathijssen NMC, Niesten DD, Riedijk R, Rijnberg WJ, Koëter S, Kremers van de Hei K, Tuinebreijer WE, Molenaar TL, Nelissen RGH et al: More complications in uncemented compared to cemented hemiarthroplasty for displaced femoral neck fractures: a randomized controlled trial of 201 patients, with one year follow-up. BMC
Musculoskeletal Disorders 2017, 18(1):169.

24. Sadr B, Arden GP: A comparison of the stability of Proplast-coated and cemented Thompson prostheses in the treatment of subcapital femoral fractures. Injury-international Journal of The Care of The Injured 1977, 8(3):234-237.

25. Santini S, Rebeccato A, Bolgan I, Turi G: Hip fractures in elderly patients treated with bipolar hemiarthroplasty: comparison between cemented and cementless implants. Journal of Orthopaedics and Traumatology 2005, 6(2):80-87.

26. Sonneholm S, Walter S, Jensen JS: Moore Hemi-Arthroplasty with and Without Bone Cement in Femoral Neck Fractures: A Clinical Controlled Trial. Acta Orthopaedica Scandinavica 1982, 53(6):953-956.

27. Talsnes O, Hjelmstedt F, Pripp AH, Reikeras O, Dahl OE: No difference in mortality between cemented and uncemented hemiprosthesis for elderly patients with cervical hip fracture. A prospective randomized study on 334 patients over 75 years. Archives of Orthopaedic and Trauma Surgery 2013, 133(6):805-809.

28. Prashanth YS, Niranjan M: Comparative Study of Surgical Management of Fracture Neck of Femur with Cemented Versus Uncemented Bipolar Hemiarthroplasty. Journal of Clinical and Diagnostic Research : JCDR 2017, 11(2):RC17-RC21.

29. Khorami M, Arti H, Aghdam AA: Cemented versus uncemented hemiarthroplasty in patients with displaced femoral neck fractures. Pakistan journal of medical sciences 2016, 32(1):44-48.

30. Gavaskar A, Tummala N, Muthukumar SU: Cemented or cementless THA in patients over 80 years with fracture neck of femur: a prospective comparative trial. Musculoskeletal surgery 2013, 98(3):205-208.

31. Khan RJK, Macdowell A, Crossman P, Keene GS: Cemented or uncemented hemiarthroplasty for displaced intracapsular fractures of the hip--a systematic
32. Ahn J, Man L, Park S, Sohl JF, Esterhai JL: Systematic Review of Cemented and Uncemented Hemiarthroplasty Outcomes for Femoral Neck Fractures. Clinical Orthopaedics and Related Research 2008, 466(10):2513-2518.

33. Lin FF, Chen YF, Chen B, Lin CH, Zheng K: Cemented versus uncemented hemiarthroplasty for displaced femoral neck fractures: A meta-analysis of randomized controlled trials. Medicine (Baltimore) 2019, 98(8):e14634.

34. Imam MA, Shehata MSA, Elsehili A, Morsi M, Martin A, Shawqi M, Grubhofer F, Chirodian N, Narvani A, Ernstbrunner L: Contemporary cemented versus uncemented hemiarthroplasty for the treatment of displaced intracapsular hip fractures: a meta-analysis of forty-two thousand forty-six hips. International Orthopaedics 2019, 43(7):1715-1723.

35. Veldman HD, Heyligers IC, Grimm B, Boymans TAEJ: Cemented versus cementless hemiarthroplasty for a displaced fracture of the femoral neck: a systematic review and meta-analysis of current generation hip stems. Journal of Bone and Joint Surgery-british Volume 2017(4):421-431.

36. Parker MJ, Gurusamy KS, Azegami S: Arthroplasties (with and without bone cement) for proximal femoral fractures in adults. Cochrane Database of Systematic Reviews 2010(6).

37. Karantana A, Boulton C, Bouliotis G, Shu KSS, Scammell BE, Moran CG: Epidemiology and outcome of fracture of the hip in women aged 65 years and under: A cohort study. Journal of Bone and Joint Surgery-british Volume 2011, 93(5):658-664.

38. Azegami S, Gurusamy KS, Parker MJ: Cemented versus Uncemented Hemiarthroplasty for Hip Fractures: A Systematic Review of Randomised Controlled Trials. HIP International 2011, 21(5):509-517.
39. Holt EM, Evans RA, Hindley CJ, Metcalfe JW: 1000 femoral neck fractures: the effect of pre-injury mobility and surgical experience on outcome. Injury 1994, 25(2):91-95.

40. Figved W, Opland V, Frihagen F, Jervidalo T, Madsen JE, Nordsletten L: Cemented versus uncemented hemiarthroplasty for displaced femoral neck fractures. Clinical orthopaedics and related research 2009, 467(9):2426-2435.

41. Donaldson AJ, Thomson H, Harper NJN, Kenny NW: Bone cement implantation syndrome. BJA: British Journal of Anaesthesia 2009, 102(1):12-22.

Supporting Information
S1 Table. Newcastle-Ottawa Scale. (Docx)
S2 Table PRISMA 2009 checklist.
S1 Figure. sensitivity analysis of (A) hip function, (B)operation time, and (C)hospital stay.
Figures
Figure 1

Flow chart detailing the selection of the studies included for the meta-analysis.

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed.1000097
|                          | Random sequence generation (selection bias) | Allocation concealment (selection bias) | Blinding of outcome assessment (detector) | Incomplete outcome data (attrition bias) | Selective reporting (reporting bias) | Other bias |
|--------------------------|-------------------------------------------|----------------------------------------|-------------------------------------------|------------------------------------------|-------------------------------------|------------|
| Chammout 2017            | +                                        | +                                      | +                                        | +                                        | +                                   | +          |
| Deangelis 2012           | ?                                        | ?                                      | +                                        | +                                        | +                                   | +          |
| Emery 1991               | +                                        | +                                      | ?                                        | +                                        | +                                   | +          |
| Inngul 2015              | +                                        | +                                      | -                                        | +                                        | +                                   | +          |
| Langslet 2014            | +                                        | +                                      | +                                        | +                                        | +                                   | +          |
| Parker 2010              | +                                        | +                                      | +                                        | +                                        | +                                   | +          |
| Sadr and Arden 1977      | ?                                        | ?                                      | ?                                        | ?                                        | ?                                   | ?          |
| Santini 2005             | ?                                        | ?                                      | ?                                        | +                                        | +                                   | +          |
Figure 2

Quality assessment of risk of bias in the studies included.
Figure 3

Forest plot of relative risk with confidence intervals for mortality.

| Study or Subgroup | Cemented Events | Total | Uncemented Events | Total | Weight | Risk Ratio M.H. Fixed, 95% CI | Risk Ratio M.H. Fixed, 95% CI |
|-------------------|-----------------|-------|-------------------|-------|--------|--------------------------------|--------------------------------|
| 6.1.1 Complication related to prosthesis |
| Chammout 2017     | 1               | 35    | 8                 | 34    | 2.4%   | 0.12 [0.02, 0.92]              |                                |
| Gavaskar 2013     | 2               | 31    | 2                 | 31    | 0.6%   | 1.00 [0.15, 6.68]              |                                |
| Inngul 2015       | 5               | 67    | 13                | 74    | 3.6%   | 0.42 [0.16, 1.13]              |                                |
| Khoram 2016       | 0               | 22    | 5                 | 29    | 1.4%   | 0.12 [0.01, 2.04]              |                                |
| Langslet 2014     | 5               | 112   | 6                 | 118   | 1.5%   | 0.96 [0.28, 3.24]              |                                |
| Parker 2010       | 2               | 200   | 1                 | 201   | 0.3%   | 2.00 [0.10, 41.09]             |                                |
| Sadr and Arden 1977 | 1             | 20    | 10                | 30    | 2.9%   | 0.10 [0.01, 0.71]              |                                |
| Santini 2005      | 1               | 53    | 2                 | 55    | 0.6%   | 0.50 [0.05, 5.35]              |                                |
| Singh 2006        | 1               | 25    | 6                 | 31    | 1.6%   | 0.19 [0.02, 1.50]              |                                |
| Sophie 2017       | 3               | 110   | 5                 | 115   | 1.8%   | 0.50 [0.12, 2.02]              |                                |
| Taylor 2012       | 3               | 80    | 3                 | 83    | 10.5%  | 0.94 [0.03, 2.94]              |                                |
| Subtotal (95% CI) | 755             | 749   | 26.9%             | 0.27 [0.17, 0.41] | |
6.1.2 Local complication

| Study          | Event | Control | Risk | 95% CI     | Z    | P    |
|----------------|-------|---------|------|------------|------|------|
| Chamnout 2017  | 35    | 34      | 1.04 | 0.32 [0.01, 7.69] | -    | -    |
| DeAngelis 2012 | 66    | 64      | 1.03 | 0.97 [0.06, 15.17] | -    | -    |
| Emery 1991     | 27    | 26      | 1.01 | 2.89 [0.12, 67.96] | -    | -    |
| Gavaskar 2013  | 31    | 31      | 1.00 | 0.80 [0.45, 1.42]  | -    | -    |
| Inglis 2015    | 67    | 74      | 0.91 | 0.55 [0.24, 1.29]  | -    | -    |
| Khorami 2016   | 22    | 29      | 0.73 | 1.32 [0.09, 19.93] | -    | -    |
| Langset 2014   | 112   | 108     | 1.00 | 0.56 [0.23, 1.38]  | -    | -    |
| Parker 2010    | 200   | 200     | 1.00 | 1.15 [0.56, 2.36]  | -    | -    |
| Prashanth 2017 | 4     | 28      | 0.14 | 10.44 [0.59, 184.57] | -    | -    |
| Sadr and Arjen 1977 | 2 | 2 | 1.00 | 0.20 [0.01, 3.92]  | -    | -    |
| Santini 2005   | 53    | 53      | 1.00 | 0.50 [0.05, 5.35]  | -    | -    |
| Singh 2006     | 25    | 29      | 0.86 | 5.77 [0.28, 114.79] | -    | -    |
| Sonne-Holm 1982| 55    | 57      | 0.96 | 1.73 [0.43, 6.88]  | -    | -    |
| Sophie 2017    | 110   | 91      | 1.24 | 1.38 [0.71, 2.67]  | -    | -    |
| Taylor 2012    | 80    | 80      | 1.00 | 0.80 [0.22, 2.87]  | -    | -    |
| Subtotal (95% CI) | 827 | 924  | 24.4% | 0.97 [0.73, 1.29] | -    | -    |

Total events: 80
Total events: 81
Heterogeneity: Chi² = 11.99, df = 14 (P = 0.61), I² = 0%
Test for overall effect: Z = 0.20 (P = 0.84)

6.1.3 General complication

| Study          | Event | Control | Risk | 95% CI     | Z    | P    |
|----------------|-------|---------|------|------------|------|------|
| Chamnout 2017  | 35    | 34      | 1.04 | 1.70 [0.55, 5.28] | -    | -    |
| DeAngelis 2012 | 66    | 64      | 1.03 | 1.02 [0.60, 1.73] | -    | -    |
| Emery 1991     | 27    | 26      | 1.01 | 1.35 [0.49, 3.71] | -    | -    |
| Gavaskar 2013  | 31    | 31      | 1.00 | 1.75 [0.57, 5.38] | -    | -    |
| Inglis 2015    | 67    | 74      | 0.91 | 0.44 [0.09, 2.20] | -    | -    |
| Khorami 2016   | 22    | 29      | 0.86 | 1.76 [0.44, 7.06] | -    | -    |
| Langset 2014   | 112   | 108     | 1.00 | 1.45 [0.42, 4.98] | -    | -    |
| Parker 2010    | 200   | 200     | 1.00 | 0.65 [0.41, 1.02] | -    | -    |
| Santini 2005   | 53    | 53      | 1.00 | 1.00 [0.60, 1.66] | -    | -    |
| Singh 2006     | 25    | 29      | 0.86 | 0.39 [0.04, 3.49] | -    | -    |
| Sophie 2017    | 110   | 91      | 1.21 | 1.10 [0.81, 1.48] | -    | -    |
| Taylor 2012    | 80    | 80      | 1.00 | 1.00 [0.56, 1.78] | -    | -    |
| Subtotal (95% CI) | 828 | 819  | 48.7% | 0.99 [0.82, 1.18] | -    | -    |

Total events: 170
Total events: 164
Heterogeneity: Chi² = 8.88, df = 11 (P = 0.69), I² = 0%
Test for overall effect: Z = 0.15 (P = 0.88)

Total (95% CI) | 2510 | 2492 | 100.0% | 0.79 [0.68, 0.91] | -    | -    |
Total events: 274
Total events: 338
Heterogeneity: Chi² = 57.67, df = 37 (P = 0.02), I² = 36%
Test for overall effect: Z = 3.27 (P = 0.001)
Test for subcategory differences: Chi² = 31.31, df = 2 (P < 0.00001), I² = 93.6%

Figure 4

Forest plot of relative risk with confidence intervals for complication.
Figure 5

Forest plot of relative risk with confidence intervals for reoperation rate (A), residual pain (B), and hip function (C).
Figure 6

Forest plot of relative risk with confidence intervals for operation time (A), and hospital stay (B).
### Figure 7

#### Summary of outcome and evidence grading

| Operation time (follow-up 12-60 months) | No of patients | Effect | Quality | Importance |
|----------------------------------------|----------------|--------|---------|------------|
| Randomised trials                      |                |        |         |            |
| Serious1                                | 833            | MD 11.70 higher (0.42 to 22.90 higher) | GOOD | LOW | IMPORTANT |
| Serious2                                | 842            |        |         |            |
| Sensitivity analysis of operation time (follow-up 12-60 months) |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| No                                        | 802            | MD 8.01 higher (6.18 to 9.85 higher) | GOOD | LOW | IMPORTANT |
| Hospital stay (follow-up 12-60 months)  |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| Serious1                                | 625            | MD 0.36 lower (1.16 to 1.87 lower) | GOOD | LOW | IMPORTANT |
| Serious2                                | 609            |        |         |            |
| Sensitivity analysis of hospital stay (follow-up 12-60 months) |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| No                                        | 595            | MD -0.04 lower (0.73 to 0.75 higher) | GOOD | LOW | IMPORTANT |
| Reoperation rate (follow-up 3-60 months) |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| Serious1                                | 26823          | RR 0.57 (0.37 to 0.90) 25 fewer per 1000 (from 6 to 34 more) | MODERATE | CRITICAL |
| Local complication (follow-up 3-60 months) |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| Serious1                                | 80927          | RR 0.97 (0.73 to 1.29) 3 fewer per 1000 (from 24 fewer to 25 more) | GOOD | LOW | IMPORTANT |
| Complication - General complication (follow-up 12-60 months) |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| Serious1                                | 170828         | RR 0.99 (0.82 to 1.18) 2 fewer per 1000 (from 36 fewer to 36 more) | MODERATE | IMPORTANT |
| Resident pain (within 2 years) (follow-up 3-60 months) |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| No                                        | 83360          | RR 0.66 (0.52 to 0.83) 11 fewer per 1000 (from 69 fewer to 168 fewer) | GOOD | HIGH | IMPORTANT |
| Hip function (follow-up 12-60 months)   |                |        |         |            |
| Sensitivity analysis of hip function (follow-up 12-60 months) |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| Serious1                                | 190            | MD 0.67 lower (1.52 lower to 3.15 higher) | DOUBLE | LOW | IMPORTANT |
| Mortality - Mortality (within 3 months) (follow-up 3-60 months) |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| Serious1                                | 101860         | RR 0.99 (0.77 to 1.28) 1 more per 1000 (from 27 fewer to 33 more) | GOOD | LOW | IMPORTANT |
| Mortality - Mortality (last follow-up) (follow-up 3-60 months) |                |        |         |            |
| Randomised trials                      |                |        |         |            |
| Serious1                                | 3921001        | RR 0.97 (0.88 to 1.08) 11 more per 1000 (from 44 fewer to 30 more) | MODERATE | CRITICAL |

1 This outcome contained some prospective studies (Gavassar 2013, Singh 2006, Prashanth 2017 and Khairi 2016), which were not RCT
2 The heterogeneity of I² was more than 50%
3 The upper or lower 95% confidence interval crossed an effect size of 0.5
4 The RR was a measure of effect (RR 0.27)
5 The 95% confidence intervals around relative effects could be very wide
Figure 8

Publication bias.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

S2 Table PRISMA 2009 checklist.doc
S1 Table Newcastle-Ottawa Scale.docx
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