REVIEW ARTICLE

Long-Term Efficacy of Screw Fixation *vs* Hemiarthroplasty for Undisplaced Femoral Neck Fracture in Patients over 65 Years of Age: A Systematic Review and Meta-Analysis

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Objective: To compare the long-term efficacy of screw fixation and hemiarthroplasty in elderly patients with undisplaced femoral neck fractures.

Methods: We searched Cochrane Library, EMBASE, and MEDLINE from inception to 10 June 2020 to identify studies about undisplaced femoral neck fracture in elderly patients over 65 years of age. The included studies were assessed by two researchers according to the Cochrane risk-of-bias criteria and Newcastle–Ottawa Scale. Meta-analysis was performed with Revman 5.3 software. The odds ratios (OR) and mean differences (MD) were used to compare dichotomous and continuous variables.

Results: A total of 750 patients were included in this meta-analysis. In elderly patients, undisplaced femoral neck fracture treated with hemiarthroplasty had a lower implant-related complication rate (*OR*, 4.05 [95% *CI*, 2.38 to 6.89]; $P < 0.00001$; $I^2 = 0$), lower reoperation rate (*OR*, 4.88 [95% *CI*, 2.84 to 8.38]; $P < 0.00001$; $I^2 = 0$), and superior Harris score (*WMD*, −5.05 [95% *CI*, −7.30 to −2.80]; $P < 0.0001$; $I^2 = 0$) in the early postoperative period. Although screw fixation was associated with shorter operative time (*WMD*, −36.22 [95% *CI*, −50.72 to −21.73]; $P < 0.00001$; $I^2 = 98\%$) and less blood loss (*WMD*, −165.84 [95% *CI*, −209.29 to −122.38]; $P < 0.00001$; $I^2 = 96\%$), there was no significant difference in long-term mortality (*OR*, 0.65 [95% *CI*, 0.28 to 1.48]; $P < 0.31$; $I^2 = 75\%$) between these two treatments.

Conclusion: In elderly patients with undisplaced femoral neck fractures, hemiarthroplasty provided a lower implant-related complication rate, lower reoperation rate, superior hip function without increased long-term mortality. Hemiarthroplasty should be recommended as a better alternative in such patients compared with multiple cannulated screws.

Key words: Elderly; Femoral neck fracture; Hemiarthroplasty; Screw fixation; Undisplaced

Introduction

Hip fractures often occur in elderly patients[1] and are one of the main causes of morbidity and mortality in the elderly population[2]. According to the National Center for Medical Statistics and published literature, about 250,000 to 310,000 hip fractures occur each year in the United States, and the number is expected to reach 500,000 between 2040 and 2050[3]. The number of hip fractures was estimated to be between 4.5 mn and 6.3 mn globally[4]. Currently, about 75% of hip fractures are female, and about 62% of hip fractures occurred over the age of 80[5]. As one of the most common classifications of femoral neck fractures, the Garden

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Received 3 July 2020; accepted 24 November 2020

Orthopaedic Surgery

classification plays a critical role in characterizing and treating femoral neck fractures[6]. Among these, Garden I and II are defined as undisplaced femoral neck fractures, while Garden III and IV are defined as displaced femoral neck fractures. For elderly patients with displaced femoral neck fractures, clinicians now reach a consensus that hip arthroplasty is recommended and preferred. But in undisplaced femoral neck fractures, percutaneous treatment with multiple cannulated screws was regularly used as a valid option in elderly patients over 65 years of age[7–10].

In recent years, some researchers reported that although percutaneous cannulated screw fixation was minimally invasive and safe, it was also associated with a high risk of femoral head necrosis, nonunion, and reoperation in elderly patients with undisplaced femoral neck fractures[10–12]. Simultaneously, others pointed out that early hip function might be unsatisfactory after screw fixation in elderly patients with undisplaced femoral neck fractures[13]. Elderly patients with such fractures who underwent screw fixation were indeed associated with a risk of poor clinical results. To identify a better treatment, some researchers directly compared the efficacy between screw fixation and hemiarthroplasty in such patients, but no consensus was reached. Some studies indicated that elderly patients treated with hemiarthroplasty could achieve fewer complications, lower reoperation rate, and better hip function in the early stage[13, 14]. But others reported no significant differences in reoperation rate and hip function between those two treatments[15, 16]. Whether hemiarthroplasty was more suitable for elderly patients with undisplaced femoral neck fractures was still controversial, and we still lack an agreement of clinical efficacy and long-term outcome between those two treatments.

Considering sufficient evidence to support clinical decisions was necessary, the purpose of our study was to compare the long-term clinical efficacy between these two treatments in patients over 65 years with undisplaced femoral neck fractures. We hypothesize that elderly patients treated with hemiarthroplasty can achieve a decreased risk of complication and reoperation with better hip function compared with screw fixation.

Material and Method

Search Strategy

The study was implemented according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement. The electronic databases including Cochrane Library, EMBASE, and MEDLINE were retrieved for related studies published from the inception of database to 10 June 2020 with no language restrictions. Clinical studies about undisplaced femoral neck fracture in elderly patients were searched with the combination of mesh terms and free terms as follow: ((((((((elderly[Title/Abstract] OR older[Title/Abstract])))) OR aged[Title/Abstract]) OR ("Aged"[Mesh] OR "Frail Elderly"[Mesh]))) AND (((("Fracture Fixation, Internal"[Mesh] OR "Internal Fixators"[Mesh] OR "Fracture Fixation"[Mesh] OR "Surgical Fixation Devices"[Mesh] OR "Orthopedic Fixation Devices"[Mesh])) OR ((fixation[Title/Abstract] OR screw[Title/Abstract] OR internal[Title/Abstract] OR implant[Title/Abstract])))) AND ((((hemiarthroplasty[Title/Abstract] OR "hemi-arthroplasty" [Title/Abstract] OR "hemi-arthroplasties" [Title/Abstract]))) OR ("Arthroplasty, Replacement, Hip" [Mesh] OR "Arthroplasty, Replacement"[Mesh] OR "Arthroplasty"[Mesh] OR "Hemiarthroplasty"[Mesh]))) AND ((((("femoral neck"[Title/Abstract] OR "femur neck"[Title/Abstract] OR hip[Title/Abstract]))) OR ("Femur Neck"[Mesh] OR "Femoral Neck Fractures"[Mesh]))) AND ((undisplaced [Title/Abstract] OR non-displaced[Title/Abstract] OR non-displaced[Title/Abstract] OR stable[Title/Abstract] OR miminal[Title/Abstract] OR garden[Title/Abstract])).

Eligibility Criteria

Articles were assessed by two researchers with pre-designed eligibility criteria, independently, and any disagreements were settled by consensus. We also checked up the reference lists of related comparative studies and reviews to confirm additional relevant studies. We defined "elderly" patients as a chronological age of 65 years or older. Participants treated with percutaneously multiple cannulated screws were defined as screw fixation group, while patients who received hemiarthroplasty treatment were defined as hemiarthroplasty group.

Studies were selected based on the following inclusion criteria: (i) participant: patients over 65 with undisplaced femoral neck fracture (GardenI/II); (ii) intervention: screw fixation; (iii) comparison: hemiarthroplasty; (iv) outcome measures: reported at least one of the following outcomes: reoperation rate, mortality rate, complication rate, Harris score[17], operation duration, hospital stay, and blood loss; (v) study design: randomized controlled trials or other studies. We excluded the studies with the following properties: patients also treated with plates or other internal fixation; displaced femoral neck fracture treated with hemiarthroplasty; the mean follow-up time was less than 1 year;

Data Extraction

Data about study characteristics and outcomes were independently extracted by two researchers and double-checked. All differences and disagreements between the two researchers were settled through discussion and consensus. The recorded items of studies included author name, methodology, follow-up time, mean age, patient number, gender, and surgical methods (cannulated screw/ hemiarthroplasty). The primary outcomes included reoperation rate, mortality, complication rate, and Harris score. Secondary outcomes included operation duration, hospital stay, and blood loss. We categorized follow-up time as short-term (6 months), mid-term (12 months), and long-term (≥24 months). According to Garden classification, we defined femoral neck

fractures with Garden I/II as undisplaced femoral neck fractures.

Quality Assessments

The methodological quality for the included studies was assessed independently by two researchers based on Cochrane risk-of-bias criteria and NOS criteria (Newcastle–Ottawa Scale), and any controversy was resolved by a final consensus. Randomized controlled trials were assessed by Cochrane risk-of-bias criteria, while observational studies were assessed by NOS criteria. In Cochrane risk-of-bias criteria, each quality item was graded as low risk, high risk, or unclear risk. The seven items used to evaluate bias in Cochrane criteria were the randomization sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. While in NOS criteria, the methodological quality of the study was evaluated by scoring (range from 0 to 10) in three aspects (selection, comparability, and exposure). Eight items were used to evaluate and score in each study, a higher score represented a higher quality of methodology.

Outcome Measurement

Reoperation Rate

Reoperation was defined as any operation performed due to complications of the primary procedure, including removal of the implant, revision surgery, reduction of hip dislocation and soft-tissue debridement and lavage. We counted the number of patients requiring reoperation from the date of surgery to the last follow-up, and a lower reoperation rate meant a better success rate of initial operation.

Mortality

The ratio between the number of deaths after surgery and the total number of participants from the date of surgery to the last follow-up was defined as mortality. Any patients who died from screw fixation or hemiarthroplasty in the study interval were included in the mortality statistics. A lower mortality rate tended to imply higher surgical safety.

Complication Rate

The postoperative complications were divided into two categories: implant-related complications and total complications. The implant-related complications included osteonecrosis of femoral head (ONFH), nonunion, wound infection (superficial/deep), implant failure, dislocation, periprosthetic fractures, aseptic loosening, and neurologic damage. Besides, cardiovascular, pulmonary, urinary, and other complications were included in the total complications. The complication rate was calculated from the date of surgery to the last follow-up, and a lower complication rate was associated with a better outcome.

Harris Score

Harris score was used to evaluate the hip score, which including hip function (0–47 points), pain (0–44 points), range of motion (0–5 points), and deformity (0–4 points). Results were grouped as being excellent (≥90 points), good (89–80), fair (79–70), and poor (<70). A higher Harris score tended to indicate better postoperative rehabilitation. All patients were measured by a clinician-administered questionnaire.

Operation Duration, Hospital Stay, and Blood Loss

Perioperative parameters such as operation duration, hospital stay, and blood loss were compared between the two groups. The relevant data were recorded by predetermined researchers. Operation duration was measured from the time of incision to the completion of skin suture. The hospital stay was the time from admission to discharge, in days. The patient's intraoperative blood loss volume was recorded as blood loss. A decreased operation duration, hospital stay, and blood loss were associated with better postoperative recovery.

Statistical Analysis

The statistical analysis of studies was performed with Revman 5.3 software. Dichotomous outcomes (reoperation rate, mortality rate, and complication rate) were analyzed with an odds ratio (*OR*), and weighted mean difference (*WMD*) was used to calculate continuous data (Harris score, operation duration, hospital stay, and blood loss) with 95% confidence interval (*CI*). Q and I^2 test were used to estimate the heterogeneity among studies. The I^2 test was used to assess heterogeneity based on the thresholds reported in the Cochrane Handbook for Systematic Reviews of Interventions: 0%–40% might not be important, 30%–60% may represent moderate heterogeneity, 50%–90% may represent substantial heterogeneity, and 75%–100% may represent considerable heterogeneity. When I^2 was less than 50% or $P > 0.1$, the fixed-effect model was applied for the meta-analysis; on the contrary, when I^2 was greater than 50% or $P < 0.1$, the random-effect model should be adopted. Forest plots were used to present the results of the individual studies and pooled estimates of effect size, respectively.

Result

Study Selection and Pooled Analysis

A total of 1741 potentially relevant citations were extracted from the three electronic databases, of which 827 articles were excluded because of duplicates and 902 articles were removed after reading the title or abstract. The full text of 12 articles was read and, eventually, two randomized controlled trials and four high-quality retrospective studies with 750 patients were considered to meet the eligibility criteria and included in the meta-analysis after screening the full text. All studies were published between 2004 and 2020, and the process of selecting appropriate studies was shown in a flow diagram (Fig. 1). There were 412 cases in the screw fixation group and 338 cases in the hemiarthroplasty group. Three studies[13–15] found

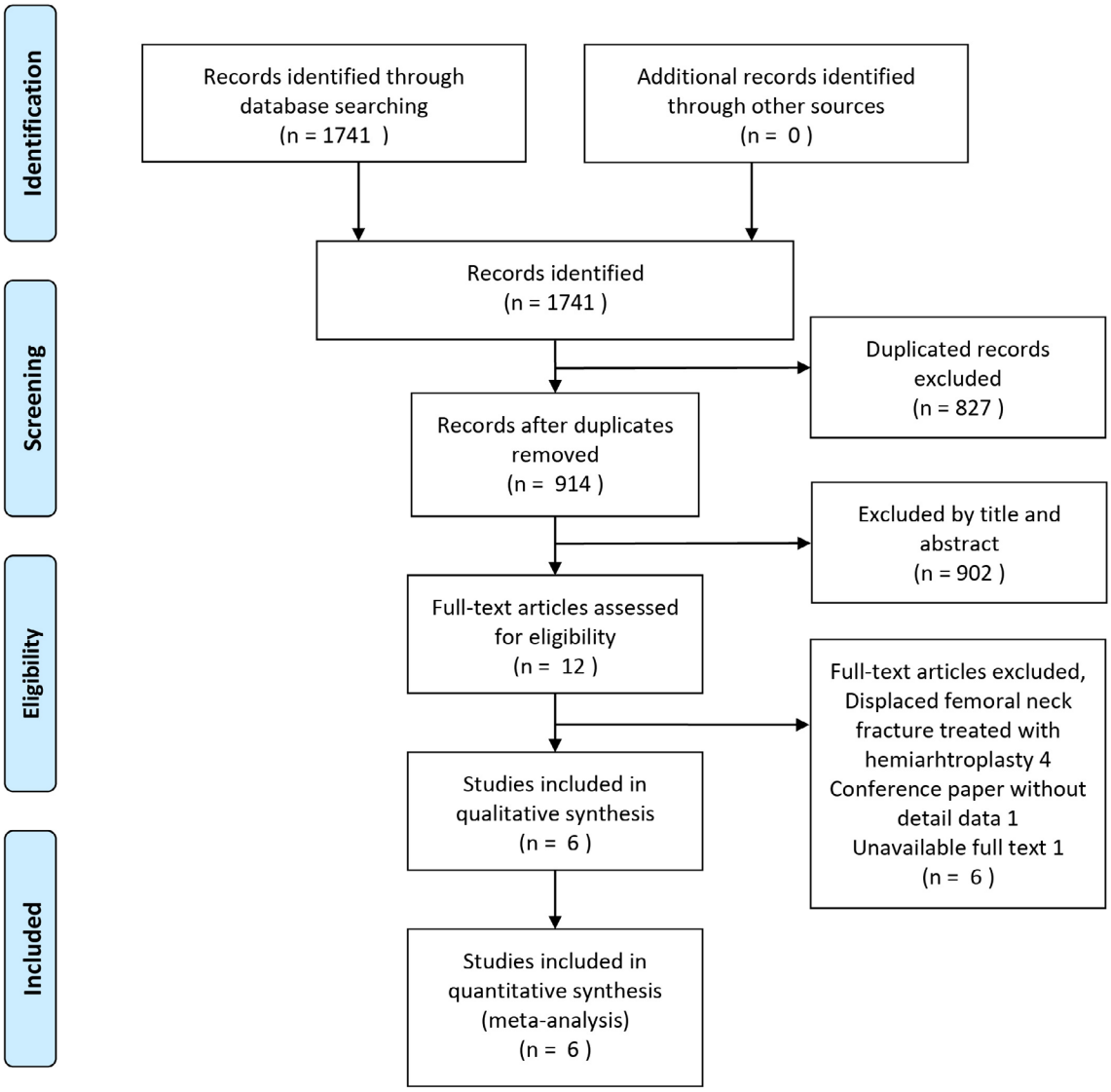

Fig. 1 Flow diagram based on the PRISMA (Preferred Reporting Items for Systematic Meta-Analyses) guidelines.

hemiarthroplasty was associated with less postoperative complications. Elderly patients treated with hemiarthroplasty had a lower reoperation rate was reported in three studies[13,14,16]. Chen *et al.*[18,19] pointed out there was no significant difference in mortality rate in the midterm follow-up, while Sikand *et al.*[20] found a significant increase in mortality when treating with hemiarthroplasty. Two studies[13,19] reported better hip function recovery in elderly patients who received hemiarthroplasty, but another two[14,16] suggested there was no significant difference in functional recovery.

Study Characteristics

A total of 750 elderly patients were included in this systematic meta-analysis, in which 412 patients treated with multiple cannulated screws (screw fixation group) and 338 patients underwent hemiarthroplasty treatment (hemiarthroplasty group). All of the included studies reported the information about author name, the gender of participants, publication year, age, surgical method, follow-up time, and at least one outcome. Three studies[13,15,16] provided information about ASA grade (American Society of Anesthesiologists). All of the studies enrolled patients over 65 years of age with undisplaced femoral neck fractures. The longest average follow-up was 55 months and the shortest was 12 months. The detailed information about the included studies was displayed in Table 1.

Assessment of Risk of Bias

Two RCTs and four high-quality retrospective studies were included in this meta-analysis. In two randomized controlled

Table 1 The characteristics of included studies

Study	Design	Mean age (years)	Patients number	Male/ Female	Comparison	Mean follow-up (months)	Outcome
Lu *et al.*[13]	RCT	86	78	20/58	MCS HA	38.7	ACDEFG
Dolatowski *et al.*[16]	RCT	83	219	62/157	MCS HA	24	ABCDEFG
Sikand *et al.*[20]	Retrospective study	78	139	33/106	MCS HA	12	ABC
Kang *et al.*[15]	Retrospective study	75	143	45/98	MCS HA	36.8	ABC
Hu *et al.*[19]	Retrospective study	68	41	11/30	MCS HA	30	ABCDEFG
Chen *et al.*[14]	Retrospective study	77	130	49/81	MCS HA	55	ABCDEFG

A, reoperation rate; B, mortality; C, complication rate; D, Harris score; E, operation duration; F, hospital stay; G, blood loss; HA, hemiarthroplasty; MCS, multiple cannulated screws.

trials, Dolatowski *et al.*[16] reported information about random sequence generation and allocation concealment, but the patients and surgeons were not blinded to the trial treatments. Lu *et al.*[13] did not offer detailed information about allocation concealment and blinding of participants and personnel. All retrospective studies were conducted with hospital controls in the selection of controls, and they also did not describe the non-response rate. The detailed quality assessment for each study was summarized in Table 2 and Fig. 2.

Reoperation Rate

Six studies[13–16,19,20] involving 750 patients reported reoperation rate after screw fixation and hemiarthroplasty. A significant difference was found between the two groups (*OR*, 4.88 [95% *CI*, 2.84 to 8.38]; $P < 0.00001$; $I^2 = 0$). Elderly patients who underwent screw fixation had a higher reoperation rate compared with hemiarthroplasty in long-term follow-up. The most common causes of reoperation in screw fixation were nonunion (28/412) and femoral head avascular necrosis (29/412), while in hemiarthroplasty group, deep wound infection (6/338) and prosthesis loosening (4/338) were the primary causes for postoperative revision. The incidence of reoperation in the screw fixation group (18.6%) was at least three times that in the hemiarthroplasty group (5.9%) (Fig. 3).

Table 2 The Newcastle–Ottawa Scale (NOS) for assessing the retrospective studies

Study	Selection	Comparability	Exposure	Total scores
Chen *et al.*[14]	***	**	**	7
Hu *et al.*[19]	***	**	**	7
Kang *et al.*[15]	***	*	**	6
Sikand *et al.*[20]	***	*	**	6

Mortality

Detailed information about the mortality was provided by five studies[14–16,19,20]. Lu *et al.*[13] provided mortality as a cumulative survival curve without specific numbers of patients which was not included in this meta-analysis. There was no significant difference in long-term mortality between these two treatments (*OR*, 0.65 [95% *CI*, 0.28 to 1.48]; $P = 0.31$; $I^2 = 75\%$). Considering the significant heterogeneity across the studies, we conducted subgroup analysis to explore the source of heterogeneity (Fig. 4).

Complication Rate

The complication rate was reported in six studies[13–16,19,20] with 750 elderly patients. We classified complications into implant-related complications and total complications. The pooled result reported a significantly higher incidence of implant-related complications in screw fixation (*OR*, 4.05 [95% *CI*, 2.38 to 6.89]; $P < 0.00001$; $I^2 = 0$), but there was no significant difference in total complication rate between the two treatments. Femoral head necrosis (7.0%) and nonunion (7.0%) were the two most common complications in screw fixation, while in the hemiarthroplasty, the primary complications included infection (1.8%), prosthesis loosening (1.5%) and dislocation (1.5%) (Fig. 5).

Harris Score

Harris score was an important outcome measure for understanding hip function postoperatively. A total of four studies[13,14,16,19] including 468 participants reported Harris score. Hemiarthroplasty group showed significant difference at short-term follow up (6 months, *WMD*, −5.05 [95% *CI*, −7.30 to −2.80]; $P < 0.0001$; $I^2 = 0$). But there was no significant difference at 12 months (*WMD*, −2.18 [95% *CI*, −4.56

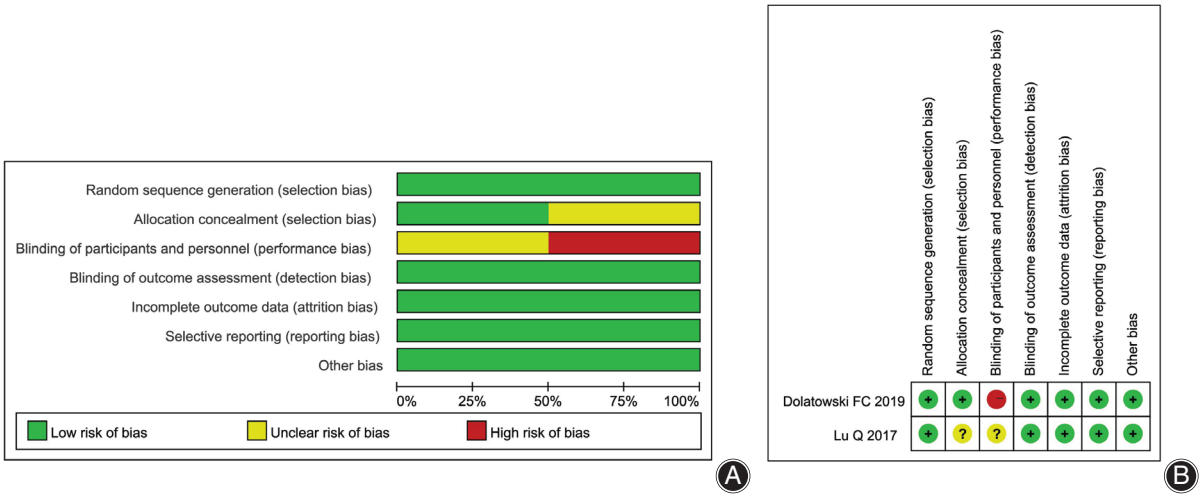

Fig. 2 Cochrane risk-of-bias criteria for randomized controlled trials.

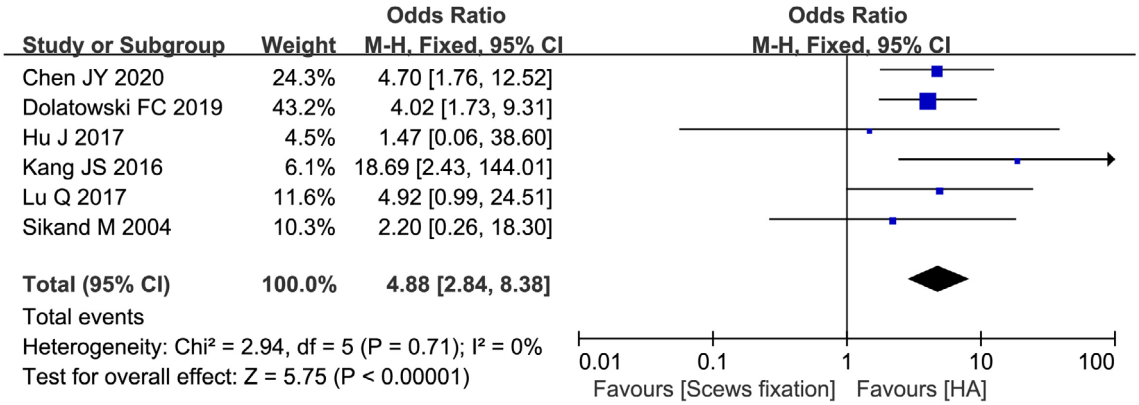

Fig. 3 Comparison of the reoperation rate between screw fixation and hemiarthroplasty. Hemiarthroplasty had a significantly lower reoperation rate compared with screw fixation.

to 0.21]; $P = 0.07$; $I^2 = 0$), and long-term follow-up (24 months, *WMD*, 0.73 [95% *CI*, −1.48 to 2.94]; $P = 0.52$; $I^2 = 0\%$). These results demonstrated that hemiarthroplasty allowed elderly patients to gain better hip function at an early stage, but there was no difference in the long-term between the two treatments (Fig. 6).

Operation Duration, Hospital Stay, and Blood Loss

Four studies[13,14,16,19] reported information about operation duration, hospital stay, and blood loss. Elderly patients who underwent internal fixation were related to less blood loss (*WMD*, −165.84 [95% *CI*, −209.29 to −122.38]; $P < 0.00001$; $I^2 = 96\%$), shorter operation duration (*WMD*, −36.22 [95% *CI*, −50.72 to −21.73]; $P < 0.00001$; $I^2 = 98\%$) and shorter hospital stay (*WMD*, −3.32 [95% *CI*, −4.28 to −2.35]; $P < 0.00001$; $I^2 = 78\%$). Although the heterogeneity of the three observational indicators above was large, subgroup analysis was not required because the results of each study within the group were consistent. Screw fixation could provide superior results in operation duration, hospital stay, and blood loss in such patients (Fig. 7).

Discussion

This systematic review assessed the long-term clinical outcomes of undisplaced femoral neck fractures between multiple cannulated screws and bipolar hemiarthroplasty in elderly patients over 65-year old. Our results supported that in elderly patients, undisplaced femoral neck fracture treated with screw fixation had a significantly higher incidence of reoperation and implant-related complications. Although percutaneous screw fixation was associated with shorter operative time and less blood loss, there was no significant difference in long-term mortality between these two treatments. Hemiarthroplasty had a lower implant-related complication rate, reoperation rate, and superior hip function in the early postoperative period. Hemiarthroplasty could be

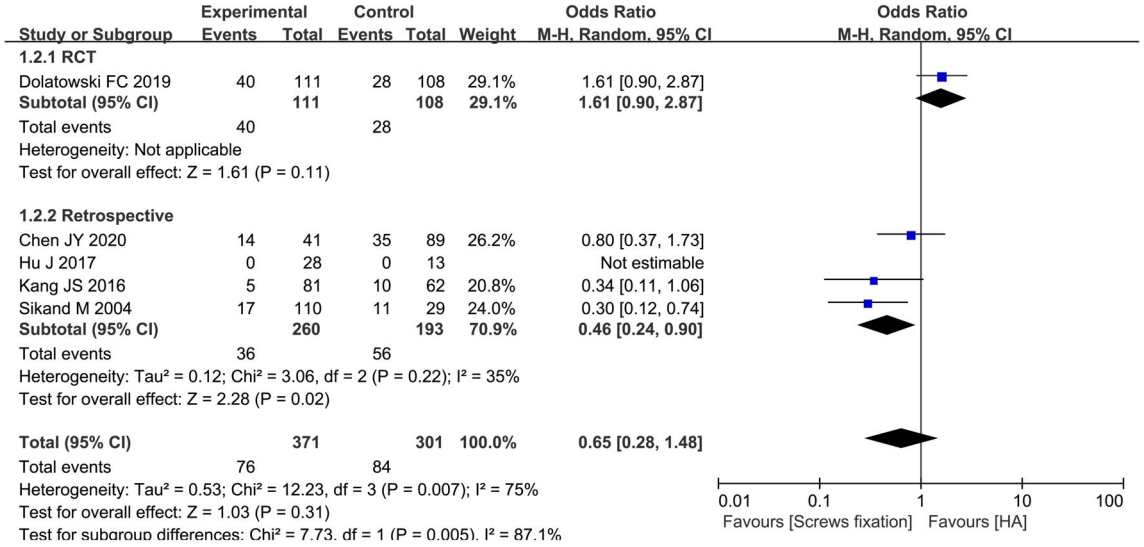

Fig. 4 Comparison of the mortality between screw fixation and hemiarthroplasty. There was no significant difference in mortality between the two treatments.

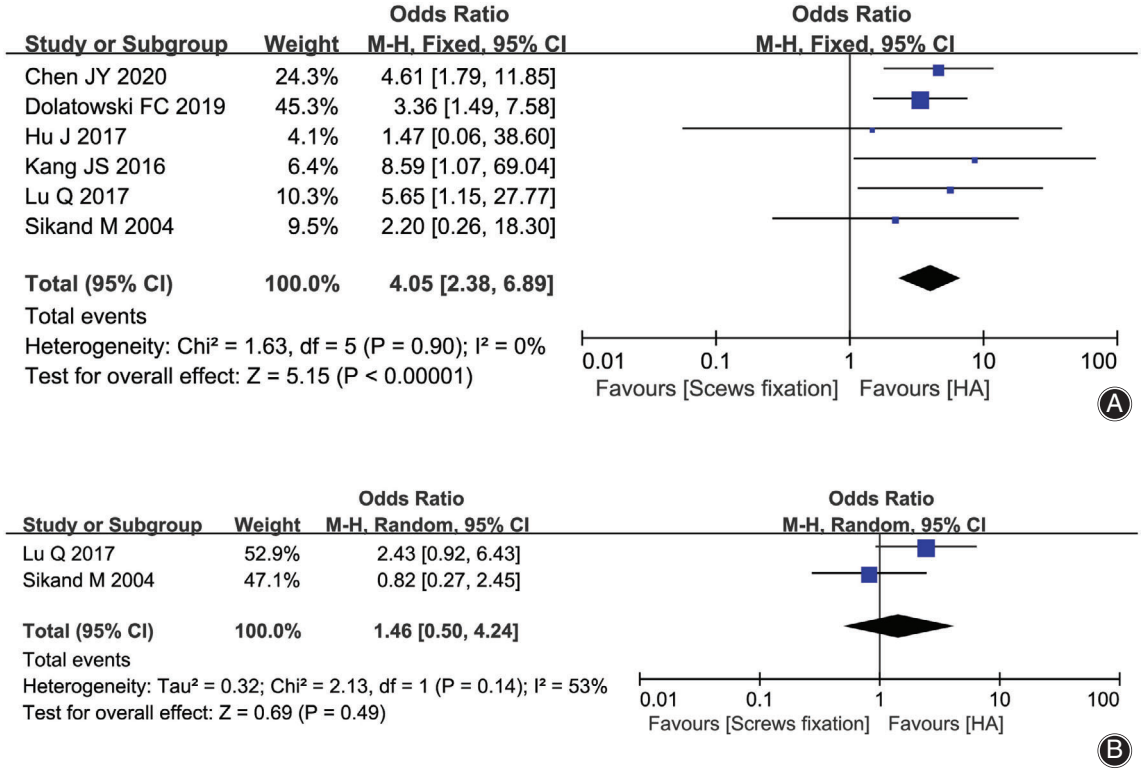

Fig. 5 Comparison of the complication rate between screw fixation and hemiarthroplasty. (A) implanted-related complication rate, (B) total complication rate. Hemiarthroplasty had a significantly lower implanted-related complication rate compared with screw fixation.

applied as a better alternative in elderly patients with undisplaced femoral neck fractures compared with multiple cannulated screws.

According to current literature, multiple percutaneous cannulated screws were more common in elderly patients with undisplaced femoral neck fractures. Surgeons found the

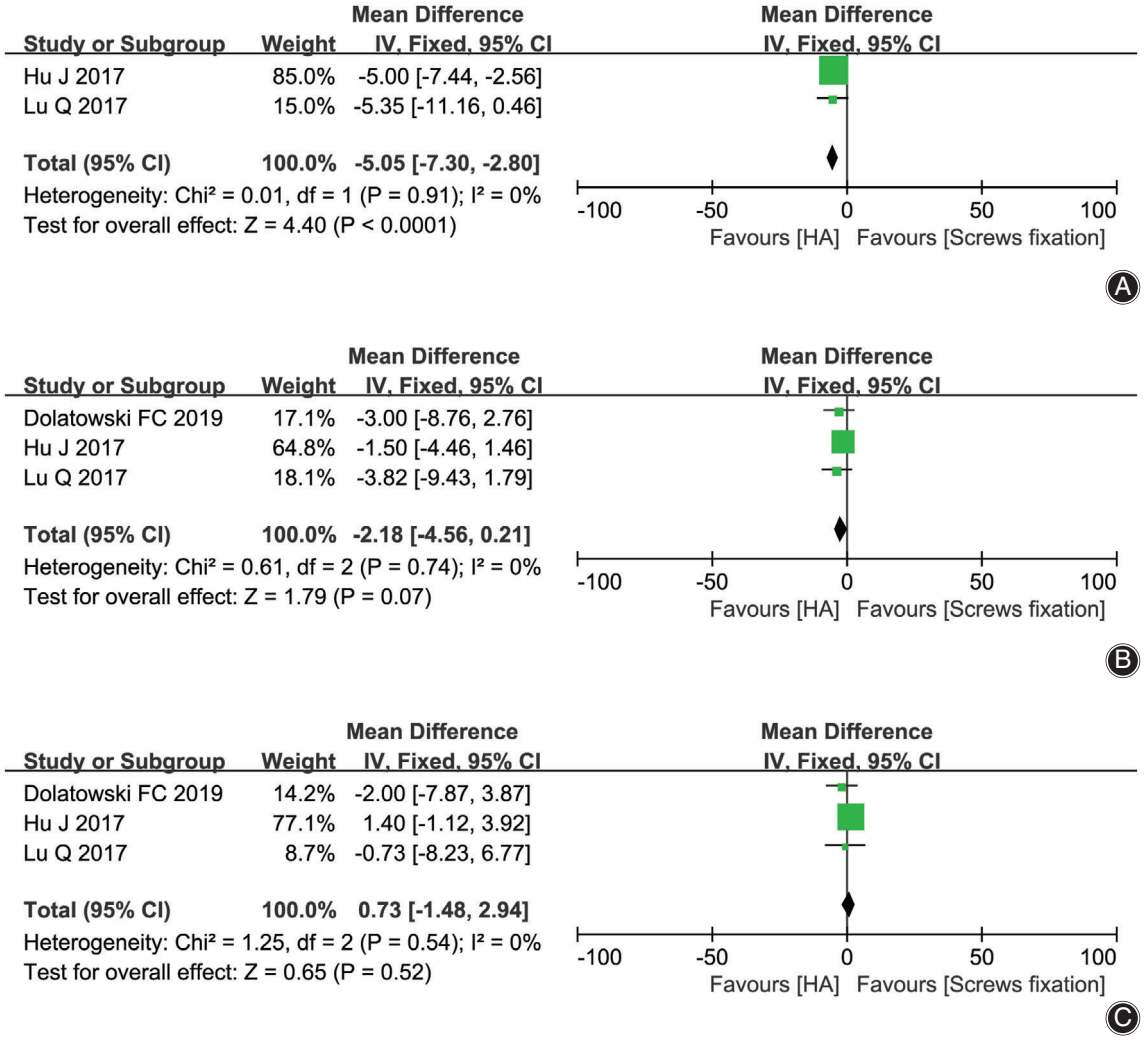

Fig. 6 Comparison of the Harris score between screw fixation and hemiarthroplasty. (A) 6-months of Harris score, (B) 12-months of Harris score, (C) 24-months of Harris score. Hemiarthroplasty had significantly superior short-term Harris score compared with screw fixation, but there was no significant difference in Harris score after 12 months postoperatively.

reoperation rate of undisplaced femoral neck fractures in patients over 60 years was about 4.5%[10]. But for patients over 70 years of age, the incidence of reoperation would increase to 20%–30%[11,16]. Our meta-analysis revealed that the reoperation rate in elderly patients treated with screw fixation was 18.6%, which was about three times that in patients treated with hemiarthroplasty. Osteonecrosis of femoral head and nonunion were the primary causes for reoperation after internal fixation. Furthermore, high preoperative anterior tilt or posterior tilt, low bone mineral density, patient age, gender, and higher body mass could increase the risk of reoperation in Garden I and II femoral neck fractures treated with cannulated screws[21–25]. Screw fixation could not provide a satisfactory long-term reoperation rate in elderly patients with undisplaced femoral neck fractures.

As a minimally invasive treatment, screw fixation in elderly patients did not have an optimistic incidence of complications. Undisplaced femoral neck fractures treated with screw fixation in such patients had a higher risk of implant-related complications compared with hemiarthroplasty. In our result, major complications of screw fixation included osteonecrosis of femoral head (7%), nonunion (7%), and implant failure (1.7%). The complications of hemiarthroplasty mainly included infection (1.8%), prosthesis loosening (1.5%), and dislocation (1.5%). Lu *et al.*[13] found so many implant-related complications would increase the total complication rate of internal fixation. Sikand *et al.*[20] reported a higher incidence of chest infection in internal fixation than hemiarthroplasty, but Dolatowski *et al.*[16] found that patients treated with screw fixation were less likely to develop pulmonary complications. In this meta-analysis, we

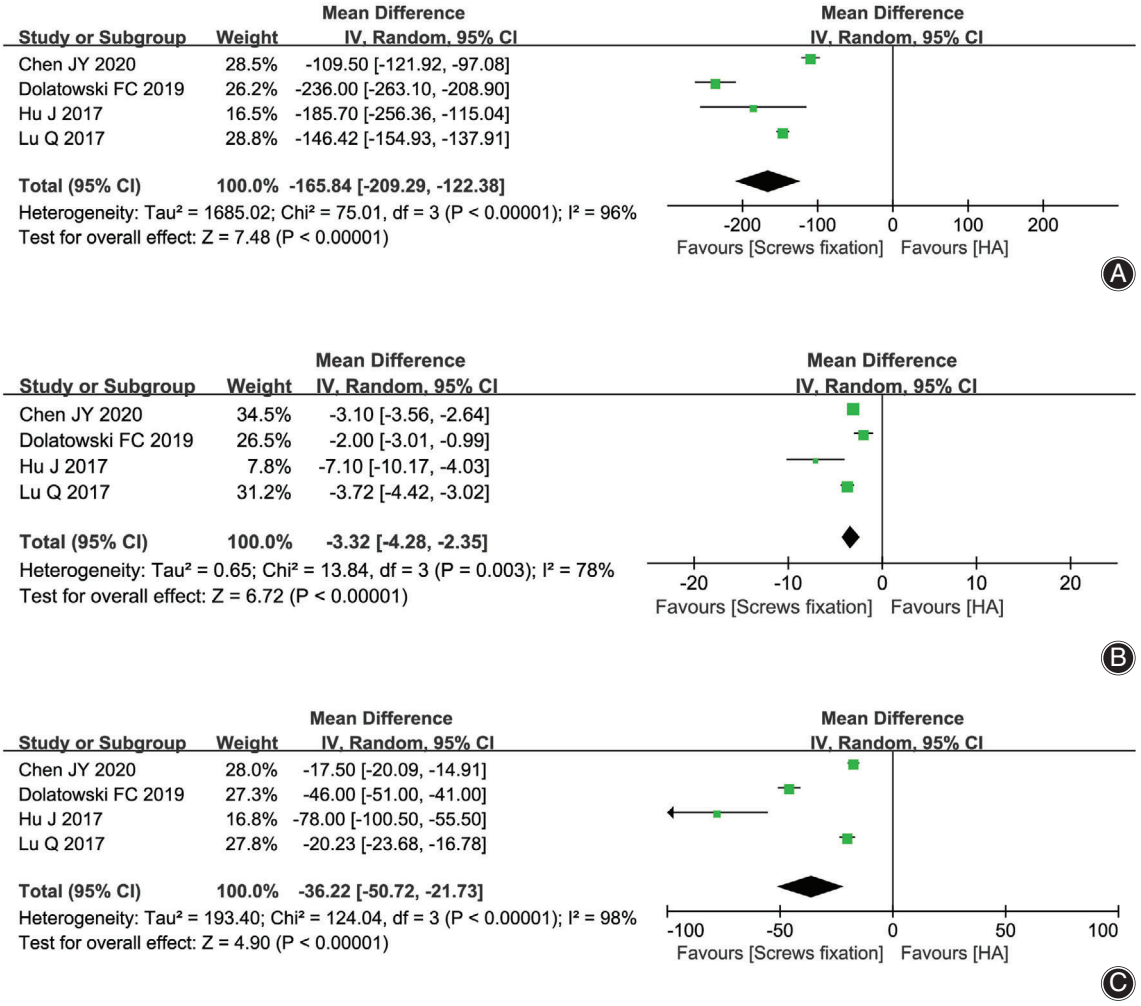

Fig. 7 Comparison of the Harris score between screw fixation and hemiarthroplasty. (A) blood loss, (B) hospital stay, (C) operation duration. Screw fixation had significantly superior blood loss, hospital stay, and operation duration compared with hemiarthroplasty.

found screw fixation indeed had a higher incidence of implant-related complications, but there was no significant difference in total complication rate compared with hemiarthroplasty. Given that only two studies[13,20] provide detailed total complication rates, further research is necessary to validate the findings.

Because of more blood loss and longer operation duration, some surgeons worried that hemiarthroplasty would increase the mortality in such patients[26], which was also one of the reasons why screw fixation was common. However, the result of our meta-analysis demonstrated that there was no significant difference in long-term mortality between the two treatments. Elderly patients treated with hemiarthroplasty did not increase long-term mortality. Lu *et al.*[13] conducted a 5-year follow-up randomized controlled trial, they found no significant difference in survival time between internal fixation and hemiarthroplasty. Dolatowski *et al.*[16] also reported undisplaced femoral neck fracture treated with hemiarthroplasty in patients over 70 years did not increase the mortality at 12 months and 24 months postoperatively. All of these results supported that although elderly patients who received hemiarthroplasty would face more blood loss and longer operation duration, this method did not increase their long-term mortality compared with screw fixation.

Another reason why screw fixation was often used in elderly patients with undisplaced femoral neck fractures was that some scholars believed a comparable hip function could be achieved by screw fixation[14,16]. Nevertheless, Lu *et al.*[13] found elderly patients treated with hemiarthroplasty had an excellent hip function and higher Harris score than screw fixation at early stage postoperatively, but there was no significant difference in long-term and final follow-up. Dolatowski *et al.*[16] also reported hemiarthroplasty could improve mobility in elderly patients (>70 years of age) with undisplaced femoral neck fracture. Our results supported

that hemiarthroplasty could achieve a better hip function in elderly patients with undisplaced femoral neck fracture at the early stage of postoperation, but there was no difference after 12 months postoperatively.

Moreover, the cost-effectiveness of undisplaced femoral neck fractures in elderly patients was also an important focus[27–29]. Traditionally, the cost of cannulated screws tends to be less than hemiarthroplasty. However, current research about the cost-effectiveness of undisplaced femoral neck fractures in elderly patients were limited and controversial. Shields *et al.*[27] retrospectively analyzed 475 patients over 65 years with femoral neck fractures. Of these, patients with non-displaced femoral neck fractures treated with cannulated screws while others underwent hemiarthroplasty. They found the average hospital charges per patient in hemiarthroplasty were higher than those in cannulated screws. However, a study conducted by Yong *et al.*[30] seemed more convincing. They directly compared the cost-effectiveness of screw fixation and hemiarthroplasty in elderly patients with undisplaced femoral neck fractures. Astonishingly, hemiarthroplasty was associated with better quality adjusted life years (QALYs) and lower cost compared to screw fixation. Although the conclusions about cost-effectiveness were inconsistent, the overall cost of cannulated screws in elderly patients with undisplaced femoral neck fractures was indeed associated with an extra cost of rehabilitation, reoperation, nursing home, and community-based care[31]. All of these costs would increase the total cost of screw fixation in such patients, even years after surgery. Those additional expenses of screw fixation also explained the tendency to be less expensive in elderly patients with undisplaced femoral neck fractures who underwent hemiarthroplasty.

This study was the first meta-analysis to evaluate the efficacy of screw fixation and hemiarthroplasty based on long-term follow-up in patients over 65 years with undisplaced femoral neck fractures. Our study provided important evidence that bipolar hemiarthroplasty was an ideal alternative for elderly patients with undisplaced femoral neck fractures. However, several limitations should be recognized. First, there were few numbers of randomized studies published currently, we included some retrospective studies to expand our sample size. Second, most of our studies enrolled the patients with low ASA grade, which meant that the conclusions of our study might be more appropriate for those elderly patients with ASA grade 1 to 3. In addition, only two studies provided detailed data about total surgery complications, the pooled outcomes in our meta-analysis need more validations. Finally, we still lack enough evidence to validate which treatment was more cost-effective, further relevant studies were necessary.

Conclusion

The present results of this meta-analysis demonstrated that bipolar hemiarthroplasty provided a lower incidence in reoperation and implant-related complications. Elderly patients with undisplaced femoral neck fractures treated with hemiarthroplasty could achieve better hip function at an early stage without increased long-term mortality. Hemiarthroplasty was a better alternative in elderly patients with undisplaced femoral neck fractures.

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