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The therapeutic effect of fixation using alternative implants for the treatment of hip fractures (FAITH) in elderly patients with femoral neck fractures after falls: a meta-analysis

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Abstract

Background Fixation using Alternative Implants for the Treatment of Hip fractures (FAITH) is widely used for the treatment of femoral neck fractures.

Aim This study conducted a comparative and meta-analysis of the therapeutic effects of different screw fixation methods in femoral neck fractures, with the aim of finding a better treatment.

Methods Pubmed, Embase, Cochrane Library and Web of science databases were searched using MeSH Terms combined with free words without time or language constraints. MeSH Terms were "femoral neck fractures", "Sliding Hip Screw", "Cancellous Screws", "Fixation using Alternative Implants for the Treatment of Hip fractures", "over 50 years old". The search deadline is August 15, 2024. Two researchers sifted through the retrieved literature to come up with the included literature. After a close reading of the literature, Review Manager 5.4 was used to analyze the risk of bias in the included literature, compare various indicators of different screw fixation, and make forest and funnel maps.

Results 214 literatures were retrieved from 4 databases were included in the study after screening. The bias of the included literature is good, and the randomness and blindness are clearly indicated in this paper. Pauwels Type III ($Chi^2 = 0.00$, df = 3, $I^2 = 0\%$, $z = 0.80$, $p = 0.43$), fall ($Chi^2 = 2.23$, df = 2, $I^2 = 10\%$, $z = 1.88$, $p = 0.06$) and Mortality ($Chi^2 = 4.80$, df = 2, $I^2 = 58\%$, $z = 3.53$, $p = 0.0004$) were lower in sliding hip screws than in cancellous screws. Garden type III and IV ($Chi^2 = 1.37$, df = 3, $I^2 = 0\%$, $z = 0.71$, $p = 0.48$) and Infection ($Chi^2 = 0.01$, df = 2, $I^2 = 0\%$, $z = 0.28$, $p = 0.78$) were lower in sliding hip screws than in cancellous screws (Both $p > 0.05$).

Conclusions In Femoral neck fractures, sliding hip screws have a distinct advantage over cancellous screws. This has guiding significance for clinical treatment. Elderly patients with femoral neck fractures should be given priority for fixation with sliding hip screws.

Keywords Femoral neck fractures, Fixation using alternative implants for the treatment of hip fractures (FAITH), Sliding hip screws, Cancellous screws, Meta-analysis

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Introduction

With age, the elderly are prone to bone loss and osteoporosis [1]. The elderly are prone to femoral neck fracture after falling down on the hip [2]. The neck of the femur is the slender outer and inferior portion of the femoral head that serves to connect the femur of the lower limb [3]. Femoral neck fractures represent the most prevalent type of hip injury, leading to significant hip pain and impairing the ability to stand and walk [4, 5]. Due to the considerable leverage exerted on the femoral neck, fractures in this area often exhibit significant displacement. Consequently, these injuries necessitate surgical intervention [6, 7]. Patients should receive emergency surgery at the earliest opportunity to minimize the risk of perioperative complications, enhance patient comfort, and reduce the duration of hospital stay [8].

Garden classification of femoral neck fractures: There are four types of femoral neck fractures according to the degree of displacement of the fracture [9]. Type I fractures are incomplete or embedded fractures [10]. A type II fracture is characterized as a complete fracture that occurs without any displacement [10, 11]. The type III fracture had partial displacement, abduction of the femoral head, slight external rotation and upward movement of the femoral neck [12]. The type IV fracture exhibited complete displacement, characterized by notable external rotation and superior movement of the femoral neck [13]. Type I and type II are stable fractures, and Type III and type IV are unstable fractures [14]. Fixation using alternative implants for the treatment of hip fractures (FAITH) [15] mainly targeted at Garden I and II. Surgical options for displaced (unstable) femoral neck fractures (Garden III and IV) include closed reduction internal fixation (CRIF), open reduction internal fixation (ORIF), semi-hip replacement (HA), and total hip replacement (THA) [15]. Slobogean et al. [16] randomized controlled factor trial also used alternative implant fixation for hip fracture (FAITH-2) evaluated young patients with femoral neck fractures for internal fixation with cancellous screws and sliding hip screws (SHS), and they found a potential benefit for hip function in the cancellous screw group. FAITH-2 can effectively improve functional and health-related quality of life (HRQL). The advantages of HA and THA are good long-term treatment effect and can be used in complete injury of femoral neck, but the amount of intraoperative blood loss and trauma is larger. Zheng et al. [17] evaluated intraoperative and postoperative bleeding in patients with hip fractures over 65 years of age undergoing hip surgery, and found similar amounts of intraoperative bleeding in the subgroups of semi-hip replacement, intertrochanteric femoral fracture internal fixation (A1–2 type fracture, short nail), and femoral neck fracture hollow nail internal fixation. Total hip replacement has the highest risk of bleeding of all surgical procedures. Frydendal et al. [18] performed total hip replacement on patients with severe hip osteoarthritis and indications for surgery, and found that all patients had significantly improved hip function and significantly reduced pain. This study performed a meta-analysis of the research on FAITH in the treatment of femoral neck fractures among elderly patients. It compared various outcomes, including quality of life, functional results, fracture healing rates, mortality, complications related to fractures, and repair rates following the implantation of different types of screws.

Methods

Literature retrieval and screening

The four databases pubmed, embase, cochrane library and web of science were searched in the form of subject terms combined with free words without time, language or country restrictions, and the age limited is over 50 years [19]. The database is searched in the form of MeSH Terms plus free words, in which the MeSH Terms are"femoral neck fractures","sliding hip screw","cancellous screws","fixation using alternative implants for the treatment of hip fractures","elderly". Free words are synonyms of each subject word.

Two researchers conducted a three-level screening of the retrieved literature. First, remove duplicate literature, reviews, and meta-analyses. Next, read the titles, abstracts, and methods sections of the literature and remove any literature related to various factors. Finally, download the full text, read the article carefully, and remove literature with incomplete data. The inclusion criteria for literature are: (1) alternative implants for the treatment of hip fractures (FAITH) treatment-related; (2) It must be a treatment for femoral neck fractures; and (3) the patient must be an elderly person. The exclusion criteria are: (1) duplicate literature; (2) review and meta-analysis; (3) young people, middle-aged people; (4) not related to femoral neck fracture; (5) not related to FAITH; (6) animal, non-human research; and (7) research on mechanisms of action, signaling pathways, etc.

Bias analysis

This meta-analysis encompasses two categories of bias: the bias inherent in the original literature and the bias that arises during the process of conducting the meta-analysis. There are six main categories of original literature bias, namely, selection bias, implementation bias, loss bias, measurement bias, report bias and other bias. There are three main types of bias in meta-analysis, namely, sampling bias, selection bias and in-study bias. Each bias includes low risk, high risk and unclear judgment. The review manager 5.4 software was utilized to

assess the bias situation and generate a visual representation of the identified biases [20].

Forest map

The indexes of various studies included in the literature were summarized, and the common indexes of many studies were extracted for subgroup analysis, and forest maps were drawn with review manager 5.4 for direct comparison. The forest plot is centered on a vertical null line, with multiple line segments parallel to the horizontal axis to represent each included effect size and confidence curve, and a diamond shape to describe the combined effect size and total confidence interval. The calculated p value less than 0.05 indicates a significant difference between the two groups, which is an indicator worthy of attention.

Funnel plot

The funnel plot is a straightforward scatter plot that illustrates the estimated intervention effects of an individual study, taking into account its sample size or accuracy. This tool can be utilized to detect potential risks of publication bias or other forms of bias. The advantage of funnel diagram is intuitive, the disadvantage is subjective, and there is a large error. If there is bias, the funnel plot will be missing corners. The funnel plot emphasizes the observation that all points representing the studies fall within the diagonal line denoting the confidence interval, as well as the specific positioning of these points. Heterogeneity (I^2) is inevitable in the funnel plot. The value of I^2 ranges from 0 to 100%. When $I^2 = 0\%$, there is no heterogeneity among studies; when $I^2 < 25\%$, there is mild heterogeneity among studies; when $25\% \leq I^2 < 50\%$, there is moderate heterogeneity among studies; when $50\% \leq I^2 < 75\%$, there is high heterogeneity among studies.

Statistical analysis

For bias analysis, in the bias section of Review manager 5.4 software, random sequence generation (selection bias), allocation concealment (selection bias), Random sequence generation (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other bias, i.e., from high risk, low risk or unclear risk. Review manager 5.4 software automatically generates bias risk maps. For the forest map, the included documents with common indicators were divided into subgroups, and the odds ratio (OR) of this index in the Sliding Hip Screw group and Cancellous Screws group for each document in the subgroup was calculated. Use Review manager 5.4 software and STATA software to make a forest map. The line segment parallel to the X-axis represents the 95% confidence interval (CI), indicating the authenticity of the results. The length of the line segment reflects the CI size, the black square represents the HR value, and the gray box shows the weight. The larger the box, the higher the weight. If the OR result of a literature is < 1, the line segment of 95%CI is completely < 1, and the p value is < 0.05, it indicates that the index in the Sliding Hip Screw group is significantly smaller than that in the Cancellous Screws group, which has statistical significance. For the funnel plot, the horizontal axis represents the index OR value of each included study, and the vertical axis represents the standard error of the logarithm of the effect size. Review manager 5.4 software was used to calculate and make funnel plot. The larger the sample size, the smaller the error and standard error; the larger the sample size, the closer the research dot, the narrower the confidence interval.

Results

Literature search and screening

Pubmed, embase, cochrane library and web of science databases were searched for 214 articles on fixation of hip fractures with alternative implants (FAITH) for the treatment of femoral neck fractures after falls in older adults. In the first screening, 78 duplicate references were removed. In the second screening, 119 references were removed, and what was deleted was Review and guideline 18; Meta-analysis 4; only the surgical techniques and postoperative recovery of femoral neck fractures, plate fixation and prosthesis removal were studied 38; Arthroplasty 29; Teriparatide, Vitamin D and other medications 9; osteoporosis, osteoarthritis, and fracture of the femoral shaft were not related to the femoral neck 11; young people 7; animal, mouse, dog, non-human studies 3. In the third round of screening, full article were not found or with no result 5; and 4 incomplete data removed. Finally, 8 literatures were finally included. The screening process is shown in Fig. 1. First author publication time, country/language, ethnic origin, total number, number of sliding hip screw group (A), number of cancellous screws group (B), age, number of gender/women (A vs. B), number of sliding hip screw group (a), number of cancellous screws group (b), BMI (A vs. B), mortality (A vs. B) of included literatures were extracted and compared, see Table 1.

Bias analysis

The randomness, blindness, data integrity and selection methods of the included literatures were extracted, and the bias analysis chart was made using review manager 5.3 software, see Fig. 2. The figure included risk of bias graph and risk of bias summary.

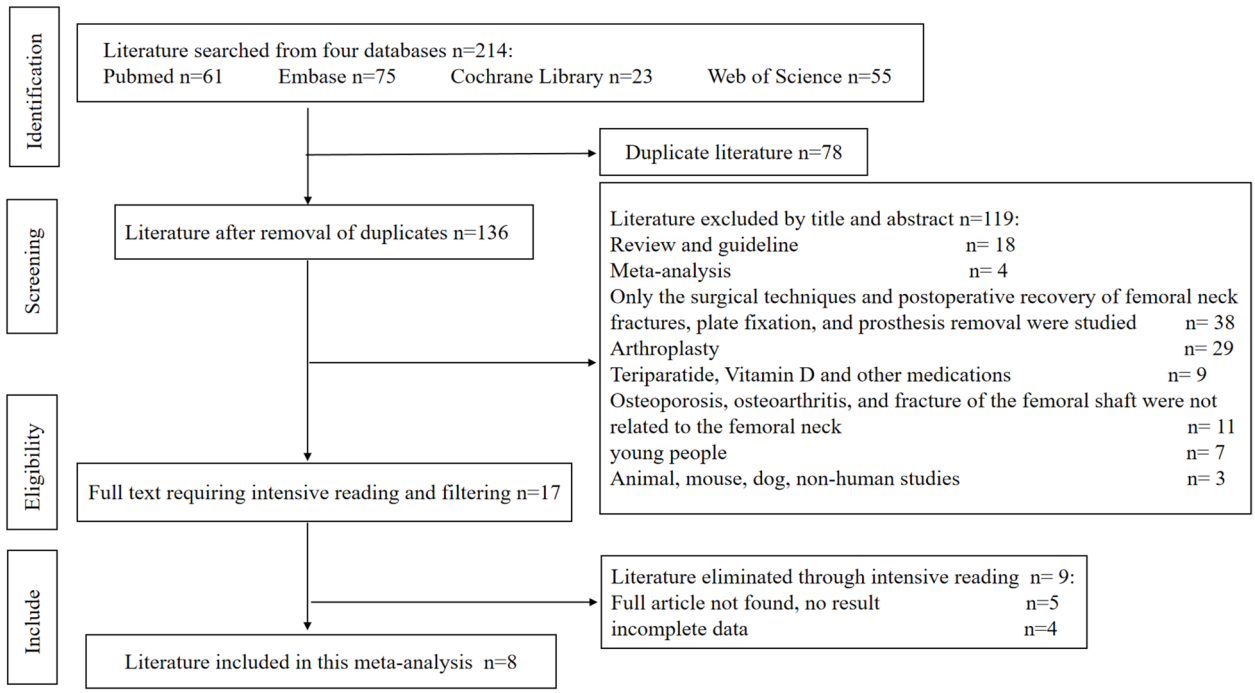

Fig. 1 Literature screening process. Two researchers conducted three rounds of screening

Forest map

Pauwels type III ($Chi^2 = 0.00$, df = 3, $I^2 = 0\%$, $z = 0.80$, $p = 0.43$), fall ($Chi^2 = 2.23$, df = 2, $I^2 = 10\%$, $z = 1.88$, $p = 0.06$) and mortality ($Chi^2 = 4.80$, df = 2, $I^2 = 58\%$, $z = 3.53$, $p = 0.0004$) were lower in sliding hip screws than in cancellous screws. Fall and Mortality were significantly lower than those in cancellous screws group ($p < 0.05$). Garden type III and IV ($Chi^2 = 1.37$, df = 3, $I^2 = 0\%$, $z = 0.71$, $p = 0.48$) and infection ($Chi^2 = 0.01$, df = 2, $I^2 = 0\%$, $z = 0.28$, $p = 0.78$) were lower in sliding hip screws than in cancellous screws (Both $p > 0.05$), and had no statistical significance, see Fig. 3.

Funnel plot

Pauwels Type III, garden type III and IV, infection, fall and mortality funnel plots all present a complete triangle of double confidence intervals, and all studies are basically inside the triangle, see Fig. 4.

Discussion

Femoral neck fracture in the elderly is a low-energy injury often encountered by orthopedic trauma surgeons in recent years. Osteoporosis is common in the elderly, and a fall and landing on the hip can lead to a fracture of the femoral neck [21]. Patients with hip fractures who cannot move their ipsilateral leg and are high risk factors for deep venous thrombosis (DVT) should be operated on as soon as possible and move out of bed as soon as possible to avoid DVT [22]. Femoral neck fractures are mainly fixed internally with screws and externally with splints or casts to ensure that the lower limbs and buttocks on the same side of the injury are immobile. The main purpose of internal fixation is to prevent displacement of stable fractures [23]. Although some studies have shown that compared with SHS, multiple cancellous screws have the advantages of relatively less trauma, shorter operative time, and adequate fixation for most stable fracture types [24, 25]. However, this study only focused on older people over the age of 50, and our findings are of certain reference value.

The main treatment for femoral neck fracture in the elderly is artificial joint replacement, to reduce the complications of the elderly in bed and improve health Quality of life [9, 26]. Cha et al. [27] compared the stability, gait and function scores of 40 mm bimovable hip replacement with 36 mm head hip replacement in elderly hip fracture patients ≥60 years. The results showed that intraoperative stability test and early gait recovery of dual mobility–total hip arthroplasty (DM–THA) were significantly better than those of macrocephalic THA ($p < 0.05$). For young femoral neck fractures, premature joint replacement is more necessary later due to the longevity of the prosthesis. The second surgical revision significantly increased the patient's pain and treatment costs, so the current treatment is still mainly fixed. Femoral neck fractures in adults are usually caused by high-energy

Table 1. Basic information about hip fracture in elderly patients with femoral neck fracture after a fall (FAITH) study

First author	Publication time	Country/ Language	Ethnic origin	Total number	Number of sliding hip screw group (A)	Number of cancellous screws group (B)	Age	Number of gender/ women (A vs. B)	BMI (A vs. B)	Mortality (A vs. B)
FAITH Investigators	2014	English	Australia, Canada, England, Germany, India, Norway, The Netherlands, and The United States	1441	750	750	50–80 years or >80 years (81 years or older))	–	–	11.0% vs.18.2%
Schottel PC	2021	USA/English	Canada, United States, United Kingdom, Germany, Norway, Netherlands, India, and Australia	898	439	459	73.0 (50–99) vs.72.8 (50–100)	279 vs. 302	–	–
Mohit Bhandari	2018	USA/English	United States, Canada, United Kingdom, Netherlands, Norway, Germany, India, Australia	1079	542	537	72.2(12.0) vs. 72.0(12.3)	330 vs. 327	25±4.5, normal BMI 52 vs. 66	73 (13%) vs. 83 (15%)
Deneka DA	1997	USA/English	USA	16	8	8	81.7 (71–87)	6	–	8 vs. 8
FAITH Investigators	2017	Canada/English	Native, South Asian, East Asian, Black, Hispanic, White	1108	557	551	72.2 (12.0) vs. 72.0 (12.3)	323/535 (60%) vs. 325/535 (61%)	Normal weight 276 (52%) vs. 300(57%)	73 (13%) vs. 83 (15%)
DeAngelis RD	2022	USA/English		819	404	415	50 years and older	–	–	–
Stengel D	2017	Germany/German	–	1079	542	537	72,2 (12,0) vs. 72,0 (12,3)	323 (60%) vs. 325 (61%)	BMI ≥25, 217 vs. 195	–
van de Kuit A	2022	Netherlands/ English	the United States, Canada, Australia, the Netherlands, Germany, Norway, the United Kingdom, and India	875	446	429	71 ± 12	531 (61%)	25±4.5	–

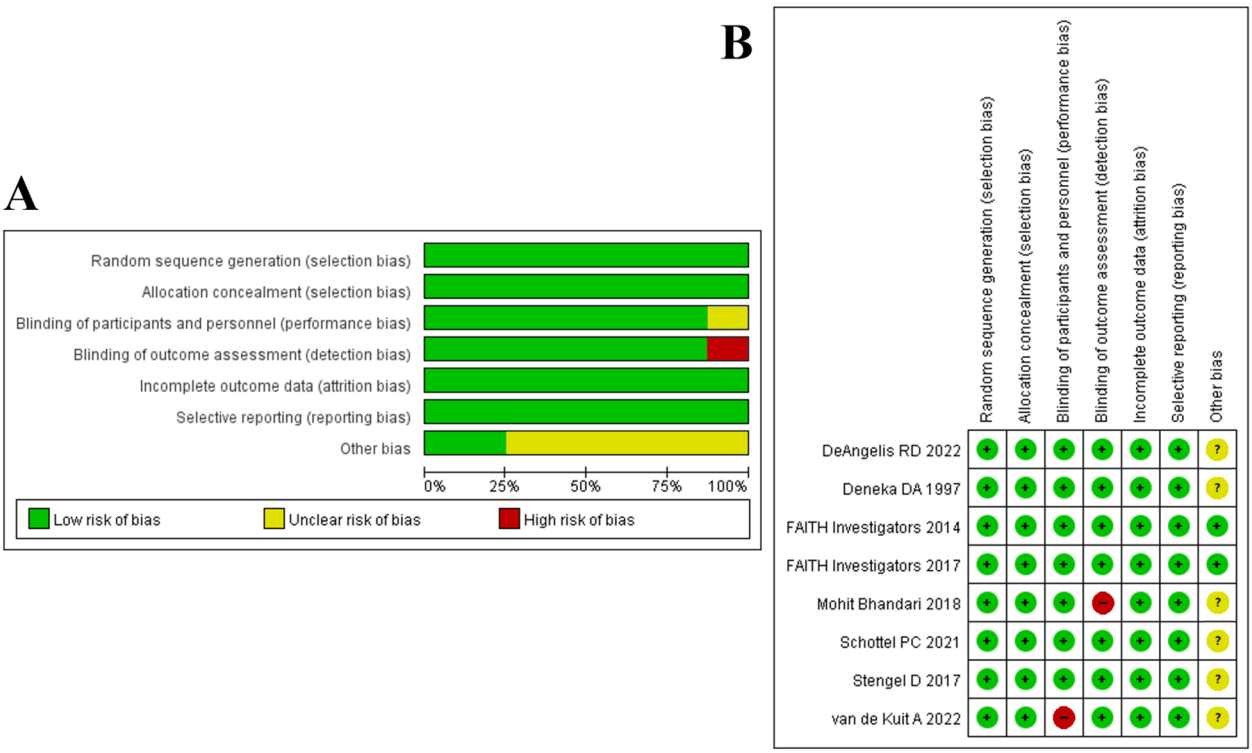

Fig. 2 Bias analysis chart. **A** Risk of bias graph. **B** Risk of bias summary

injuries [28, 29]. These high-energy injuries can lead to longitudinal fracture lines at the fracture site, which the high shear load of fracture type is also responsible for the high failure rate of femoral neck fractures after internal fixation [30]. Discussed in this paper, the goal is to synthesize current research and fixation techniques to determine how to resist the shear forces of longitudinal fractures in young patients [31]. Thus, this kind of high energy injury of femoral neck fracture can be fixed stably and securely. Xu et al. [32] studied the long-term efficacy of screw fixation and hemijoint replacement for undisplaced femoral neck fractures in patients over 65 years of age. A meta-analysis concluded that hemijoint replacement provided lower rates of prosthesis-related complications, lower rates of reoperation, better hip function, and no increased long-term mortality. Okike et al. [33] analyzed collected data from the FAITH (Fixed Use Replacement) Implant for Hip Fracture) trial, an international, multicenter, randomized controlled trial of sliding hip screw combined with hollow screw for femoral neck fracture in a 50-year-old patient. Vahabi et al. [34] retrospectively analyzed patients with intertrochanteric fracture of femur treated with cephalomedullary nails (CMN) aged 50 years or older, and compared the therapeutic effects of helical blade, screw and winged screw. The results showed that the three implants had similar results in femoral neck shortening, varus collapse, and slip, and that mechanical complications increased with reduction of reduction quality ($p = 0.000$). Jiang et al. [35] compared cancellous screws (CS) and femoral neck system (FNS) internal fixation in the treatment of femoral neck fracture, the results showed that patients in the CS group had the least blood loss, but the hospital stay was longer, and the treatment cost of CS was the lowest, and studies showed that CS combined with FNS fixation would get more satisfactory results. Primary joint replacement may be considered for elderly patients with a femoral neck fracture with a posterior inclination of > 20 in GARDEN-1 and type II. Lim et al. [36] Dynamic hip screw with hollow cancerous screw for the treatment of Pauwels type II or III femoral neck fractures, analysis results showed that vertically oriented FNFs, DHS technique was more favorable than CCS technique, and the risk of fracture nonunion was lower. Nursing also has a certain impact on the postoperative recovery of femoral neck fracture in the elderly, which is also the direction of our comparative study in the future. Sun et al. [37] provided predictive care for 82 elderly patients with femoral neck fracture, created a warm and comfortable ward environment for patients, set the indoor temperature at 22 °C, and regularly exchanged wives with the flight, provided patients with daily necessities and paid attention

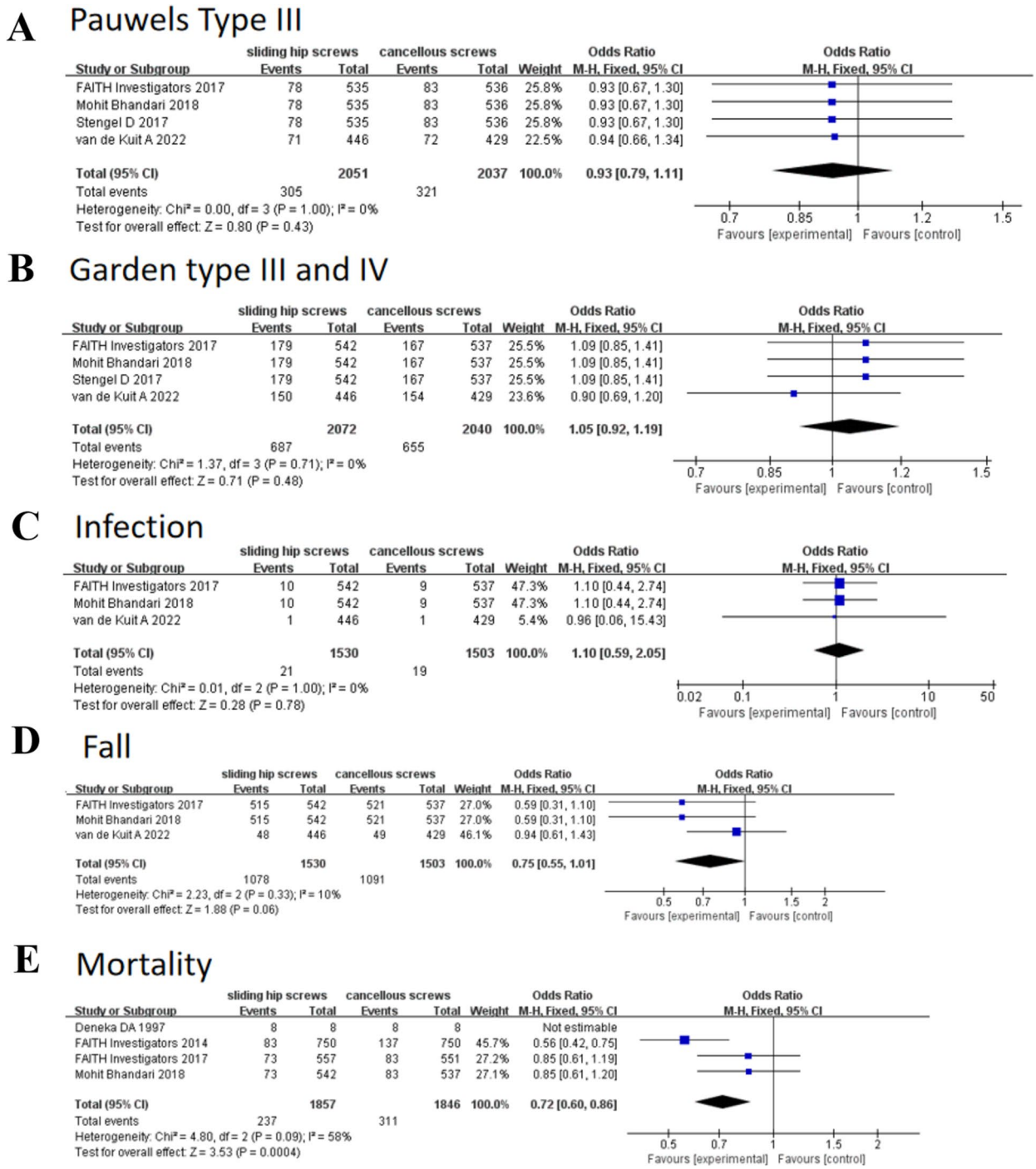

Fig. 3 Forest map of different subgroups. **A** Pauwels Type III. **B** Garden types III and IV. **C** Infection. **D** Fall. **E** Mortality

to vital signs indicators, and required nurses to actively communicate with patients and establish a good relationship, conduct psychological counseling and nursing. The results showed that patients with predictive care had significant improvement in nursing satisfaction and pain relief ($p < 0.05$). Li et al. [38] explored the impact of psychological support treatment on the psychological state, pain and quality of life of elderly patients with femoral neck fracture, and compared the postoperative routine care and psychological support therapy (PST) care of 82 elderly patients with femoral neck fracture. The results showed that the scores of anxiety, depression and pain in

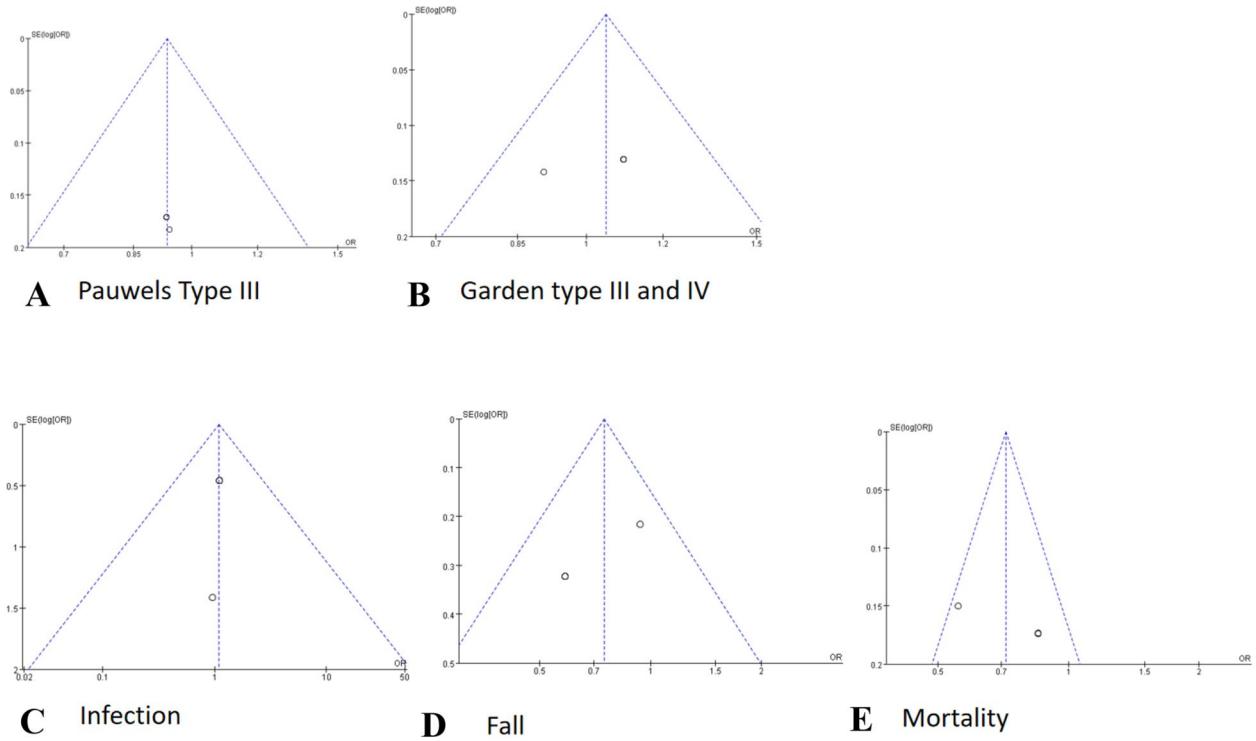

Fig. 4 Funnel diagram of different subgroups. **A** Pauwels Type III. **B** Garden types III and IV. **C** Infection. **D** Fall. **E** Mortality

PST group were significantly lower ($p < 0.05$), and satisfaction was significantly higher than that in conventional care group (92.68 vs. 75.61%, $p < 0.05$).

There are some defects in this study that need to be improved in future studies. First of all, only 4 world databases were searched in this study, and no other medical databases and excellent databases within each country were searched. This is likely to lead to the absence of included literature and may not have been taken into account during the selection process. Second, FAITH is a relatively novel method for the treatment of femoral neck fracture, which is still in the clinical research stage at present, and there will be more cases and follow-up results in the future. This requires our continuous follow-up research and timely summary. This article is only a meta-analysis of published literature up to now, and the conclusions obtained may have certain limitations. Finally, the subgroup index analysis of the included literature may not be comprehensive, so each index should be analyzed. Although some literatures do not have relevant data for specific indicators, we should take the initiative to contact the authors and complete the data as much as possible. In general, the literature included in this meta-study is relatively small, and it is not possible to evaluate postoperative recovery indicators for elderly patients with femoral neck fracture such as functional recovery, health-related quality of life (HRQL), hip outcome score and Short-Form 12 Health Survey (SF-12) were compared. We will try to conduct clinical studies in our hospital to make up for the comparison of these key indicators.

Conclusion

Alternative implants even if different must be implanted respecting the principles of osteosynthesis [39]. Pauwels Type III, fall and Mortality were lower in sliding hip screws than in cancellous screws. Garden type III and IV and Infection were lower in sliding hip screws than in cancellous screws. Overall comparison shows that FAITH sliding hip screws are better than cancellous screws, and fall and Mortality are lower than cancellous screws.

Author contributions

Sulan Long and Daofang Yu were involved in the conception and design, or analysis and interpretation of the data; Khanitta Nuntaboot, Suvapat Nakrukamphonphatn, Wangqiao Zhu and Jia Liu the drafting of the paper, revising it critically for intellectual content; Sulan Long and Daofang Yu the final approval of the version to be published; and that all authors agree to be accountable for all aspects of the work.

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Availability of data and materials
Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent for participate
Not applicable.

Consent to publication
All authors have agreed to publish.

Informed consent
All authors gave written informed consent.

Competing interests
The authors declare no competing interests.

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