



Sliding hip screws versus cancellous screws for femoral neck fractures: a systematic review and meta-analysis

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Abstract

Purpose Both sliding hip screws (SHS) and cancellous screws are used in the surgical management of intracapsular femoral neck fracture. However, there is paucity of information as to which is the superior treatment modality. We performed this systematic review and meta-analysis study to compare the clinical outcomes of SHS and cancellous screws for the treatment of femoral neck fractures in adult patients.

Methods We searched PubMed, Scopus, Web of Science, and Cochrane CENTRAL, up to December 2017. Randomized controlled trials (RCTs) directly comparing the clinical outcomes of SHS and cancellous screws for femoral neck fractures were retrieved with no language or publication year restrictions. Data retrieved included operative details, nonunion rate, avascular necrosis, reoperation, infection and mortality, hip pain, functional hip scores, and medical complications. These were pooled as risk ratio or mean difference (MD) with their corresponding 95% confidence interval (CI). Heterogeneity was assessed by Chi-square test.

Results Ten RCTs involving 1934 patients were included in the final analysis. The pooled estimate showed that the SHS group was associated with more intraoperative blood loss (MD = 110.01 ml, 95% CI [52.42, 167.60], $p = 0.00002$) than the cancellous screws. There was no significant difference in terms of operative time, postoperative hip function, nonunion, avascular necrosis, reoperation rate, infection, fracture healing, hip pain, medical complications, and mortality rate.

Conclusion Based on our study, the cancellous screws group was associated with less intraoperative blood loss in comparison with the SHS group. No other significant differences were found between the two interventions.

Keywords Femoral neck fractures · Internal fixation · Sliding hip screws · Cancellous screws

Introduction

A proximal femoral or hip fracture is a very common cause of admission to the orthopedic emergency department worldwide [1]. The incidence of hip fractures is expected to reach 2.6 million by 2025 and up to 4.5 million by 2050 on secular trends [2]. There are an estimated number of 4.5 million people per year becoming disabled after a hip fracture, with the number of people living with disability due to a hip fracture expected to increase to 21 million in the next 40 years [1, 3, 4]. These fractures occur most commonly in population above 50 years of age [5, 6]. However, young population can be prone to such fractures due to high-energy trauma in road traffic collisions and extreme sports [7–9]. Femoral neck fractures are associated with complications such as nonunion, avascular necrosis, infection, and implant failure [5, 10].

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Treatment of femoral neck fractures differs according to patient's age and the pattern of the fracture [11–13]. Management of femoral neck fractures is resource heavy requiring a large multidisciplinary team. The management pathway starts from the ambulance to the emergency room and will require input from radiology, anaesthetics, medical physicians, orthopaedic surgeons, and physiotherapy [1]. Most hip fractures are managed surgically either with arthroplasty or reduction and internal fixation, depending on the fracture configuration, age of patient, and associated comorbidities [5, 7, 14, 15]. Operative fixation of intracapsular fractures may be with cannulated cancellous hip screws or a sliding hip screws (SHS) [16]. There does not appear to be any consensus on which is more effective.

We therefore conducted this systematic review and meta-analysis to compare cancellous screws and SHS for treatment of intracapsular femoral neck fractures.

Methods

We performed all steps of this systematic review in a strict accordance with the Cochrane Handbook of Systematic Reviews and Meta-analysis [17]. We also followed the preferred reporting items for systematic reviews and meta-analyses (PRISMA statement guidelines) [18].

Literature search

We searched PubMed, Scopus, Web of Science, the Cochrane Central Register of controlled trials (CENTRAL), WHO International Clinical Trials Registry Platform, WHO GHIL, and EBSCO to identify relevant studies. Dates were inclusive up to December 2017. There were no language restrictions. The following search queries were used independently or in combination according to the medical subject headings (MESH) (“femoral neck fractures,” “intracapsular hip fractures,” “internal fixation,” “arthroplasty,” “sliding hip screws,” and “cancellous screws”). We searched ClinicalTrials.gov to identify additional relevant studies. Furthermore, we hand-searched references of the most relevant articles.

Eligibility criteria

We included RCTs comparing SHS and multiple cancellous screws in skeletally mature patients with intracapsular femoral neck fractures. We excluded observational studies, biomechanical studies, non-human studies, studies from which data could not be reliably extracted, case reports, theses, and conference abstracts.

Study selection

Three authors independently applied the selection criteria. Eligibility screening was conducted in two steps: (a) titles and abstracts screening for matching the inclusion criteria and (b) full-text screening for eligibility to meta-analysis using standardized Excel spreadsheet. Disagreements or uncertainties were resolved by consensus with another reviewer.

Data extraction

Data extraction was carried out by two researchers, while a third researcher resolved any disputes between the two main researchers. The data collected were first author's name, publication year, study design, number of participants in each group, mean age, gender, type of intervention, study period, follow-up period, and outcomes of interest.

Outcomes

We included studies including at least one of the following outcomes: (a) operative details including operative duration and intraoperative blood loss, (b) fracture fixation complications including nonunion, avascular necrosis, reoperation rate, implant failure, and infection, (c) hip function scores using Harris Hip Score (HHS), (d) medical outcomes including pulmonary embolism, cardiovascular complications, and deep venous thrombosis, and (e) final outcome measures including hip pain and mortality rate at 3 months, 2 years, and 3 years postoperatively.

Risk of bias assessment

We used Cochrane risk of bias (ROB) assessment tool [17], described in chapter 8.5 of the Cochrane Handbook of Systematic Reviews of Interventions 5.1.0 [17]. The Cochrane ROB assessment tool is designed to detect five types of bias, including selection bias (sequence generation and allocation concealment), performance bias (blinding of participants and investigators), detection bias (blinding of outcome assessors), attrition bias (incomplete outcome data), and reporting bias (selective outcome reporting). Each study was classified in each domain as low, high, or unclear risk of bias.

Data analysis

The analyses were performed using R software for windows (meta-package, version 4.9–0). For continuous outcomes, we calculated the mean difference (MD) and 95% confidence intervals (CI) for each outcome. For dichotomous

outcomes, we calculated the risk ratio (RR) and 95% CI for each outcome. An alpha level < 0.05 was considered statistically significant. The range in some studies was converted to standard deviation in accordance with the protocol provided by Hozo et al. [19].

Assessment of Heterogeneity and publication bias

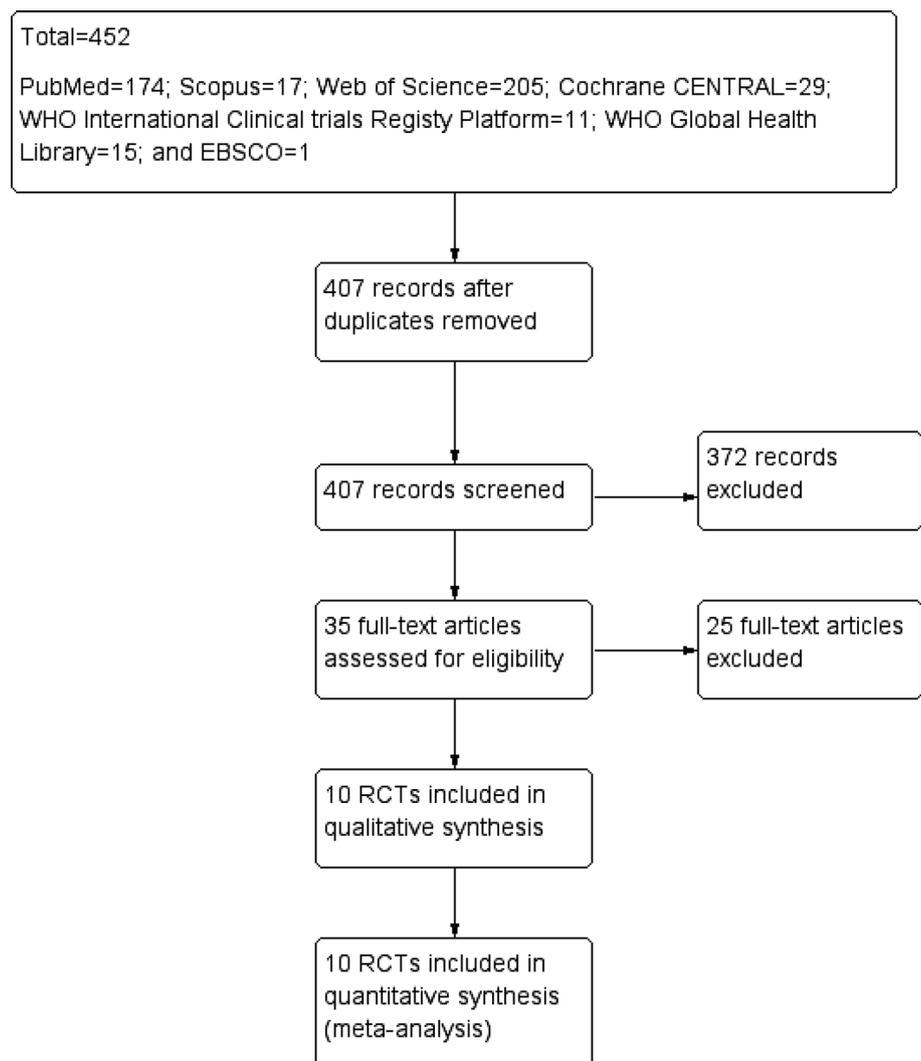
Heterogeneity was assessed by visual inspection of the forest plots and measured by Q statistic and I^2 . Significant statistical heterogeneity was indicated by a Q statistic p value < 0.1 or by I^2 more than 50%. In case of significant heterogeneity, a random effect model was employed. Otherwise, the fixed effect model was used. Subgroup analysis and sensitivity analysis were used to resolve the heterogeneity.

Results

Search strategy results

Our search retrieved 452 unique citations. After removing observational studies, biomechanical studies, non-human studies, studies from which data could not be reliably extracted, case reports, theses, and conference abstracts, 35 articles were retrieved and screened for eligibility to the meta-analysis. Of these, 25 articles were excluded because they included extracapsular fractures, used combined procedures, or compared different techniques and ten RCTs were included. The PRISMA flow diagram of study selection is shown in Fig. 1.

Fig. 1 Flow diagram of articles selection process



Baseline characteristics

Ten RCTs [16, 20–28] involving a total of 1934 patients were included. Of these, 960 patients were received a SHS and 974 patients were treated with cancellous screws. The follow-up period ranged from 2 to 4 years. All articles were published in English from 1986 to 2017. A summary of the design and baseline characteristics of enrolled patients is presented in Table 1.

Risk of bias assessment

All the included RCTs reported that the enrolled patients were randomly allocated to different study groups, but only three studies reported how randomization was performed. One used a centralized computer system [20], another study used a sealed-envelope technique [27], and the third used a simple randomization method [16]. Three trials [20, 25, 27] kept unbroken blinding. All RCTs were at low risk of bias in terms of selective reporting. Nine trials were at low risk of bias in terms of incomplete outcome of the data. Three trials [20, 25, 27] described allocation concealment, while details of blinding of the surgeons, patients, and assessors were unclear in eight trials. Summary of quality assessment of RCTs is shown in Fig. 2.

Outcomes

Operative details

Operative duration in minutes The pooled estimate of two studies [16, 22] showed no significant difference between the SHS and cancellous screws groups (MD=24.11 min, 95% CI [-24.39, 72.61], $p=0.33$, Fig. 3a). The two studies were heterogenous ($I^2=96%$, $p<0.01$); therefore, random effect model was conducted.

Intraoperative blood loss The pooled estimate from three RCTs [16, 22, 24] showed that the SHS group was associated with significantly larger intraoperative blood loss than the cancellous screws group (MD=110.01 ml, 95% CI [52.42, 167.60], $p=0.00002$, Fig. 3b). The pooled studies were heterogenous ($I^2=80%$, $p=0.006$). Heterogeneity was best resolved by excluding the study by Kuokkanen et al. [22] (MD=135.24 ml, 95% CI [112.36, 158.12], $p<0.000001$, $I^2=0%$, $p=0.59$, Fig. 3c).

Fracture fixation complications

Nonunion The pooled risk ratio showed no significant difference between the two compared groups in terms of nonunion (RR=1.05, 95% CI [0.84, 1.33], $p=0.84$). No significant heterogeneity was observed ($I^2=38%$, $p=0.15$

Fig. 4a). Nonunion rate was reported by six RCTs [16, 20, 21, 24–26].

Avascular necrosis Data on avascular necrosis were reported by nine RCTs [16, 20–26, 28]. The pooled estimate did not favor either of the two compared groups (RR=1.00, 95% CI [0.61, 1.64], $p=0.99$, Fig. 4b).

Reoperation rate The pooled estimate from nine RCTs [16, 20–26, 28] did not favor either of the two compared groups in terms of reoperation rate (RR=0.87, 95% CI [0.67, 1.12], $p=0.28$). No significant heterogeneity was detected among these studies ($I^2=35%$, $p=0.14$, Fig. 4c).

Infection The pooled estimate from five RCTs [16, 20, 21, 24, 25] was comparable between the two compared groups in terms of postoperative infection (RR=1.39, 95% CI [0.80, 2.40], $p=0.25$). Pooled studies were homogenous ($I^2=0%$, $p=0.68$, Fig. 4d).

Fracture healing The pooled risk ratio showed no significant difference in fracture healing between the two compared groups (RR=0.83, 95% CI [0.53, 1.29], $p=0.40$). The pooled three RCTs [21, 25, 26] were heterogenous ($I^2=71%$, $p=0.03$, Fig. 4e).

Hip function scores

The pooled mean difference from three RCTs [16, 20, 28] showed no significant difference in terms of postoperative hip function (MD=0.47, 95% CI [-14.89, 15.82], $p=0.95$). Pooled studies were heterogenous ($I^2=93%$, $p<0.1$, Fig. 5).

Medical outcomes

The total effect estimate showed no significant difference between the two compared groups in terms of medical complications (RR=0.98, 95% CI [0.71, 1.34], $p=0.92$, Fig. 6).

Hip pain

The pooled risk ratio from two RCTs [21, 26] did not favor either the SHS group or the cancellous screws group in terms of postoperative hip pain (RR=0.77, 95% CI [0.57, 1.05], $p=0.09$). Pooled studies were homogenous ($I^2=0%$, $p=0.34$, Fig. 7).

Mortality

Seven RCTs [16, 20–22, 25–27] reported postoperative mortality at 3 months, 2 years, and 3 years. The total effect estimate showed that the two groups were consistent in

Table 1 Baseline characteristic of included studies

References	Study design	Patients		Mean age (range)		Gender (male/female)		Interventions	Study period	Follow-up (months)	Main outcomes
		SHS	Cancellous screws	SHS	Cancellous screws	SHS	Cancellous screws				
FAITH [20]	RCT	542	537	72.2	72	212/323	210/325	SHS versus cancellous screws	2008 to 2014	24 months	Reoperation rate, mortality rate, avascular necrosis, medical complications, fracture complications
Gupta et al. [16]	RCT	40	45	40.7 (16–60)	39.3 (16–60)	23/17	32/13	SHS versus multiple cancellous screws	2010 to 2014	48 months	Hip functional scores, avascular necrosis, nonunion, mortality
Siavashi et al. [28]	RCT	30	28	30 (18–60)	28 (18–58)	25/5	21/7	DHS versus cancellous screw	2010–2014	12 to 36 months	Reoperation, avascular necrosis, nonunion, functional outcomes
Watson et al. [27]	RCT	31	29	77.9	76.7	6/25	5/24	DHS versus cancellous screw	2004 to 2010	24 months	Reoperation, nonunion rate
Benterud et al. [21]	RCT	108	117	81 (63–97)		47/178		SHS versus two uppsala/Olmed screws	–	39 months	Reoperation, avascular necrosis, nonunion, hip pain, and mortality
Sorensen et al. [26]	RCT	35	38	77 (52–94)		18/55		SHS versus three Gouffon screws	–	36 months	Nonunion, avascular necrosis, reoperations, mortality
Kuokkanen et al. [22]	RCT	17	16	60 (21–84)	72.5 (62–82)			SHS versus three cancellous screws	1985 to 1986	24 months	Nonunion, avascular necrosis, reoperations, deep wound infection, blood loss, and mortality
Madsen et al. [24]	RCT	51	52	75 (25–91)	74 (34–92)	14/37	11/41	SHS and cancellous bone screws	–	24 months	Reoperation, nonunion, avascular necrosis, and wound infection
Linde et al. [23]	RCT	40	47	76 (25–91)	76 (34–92)	16/24	14/33	SHS and four AO cancellous bone screws	–	–	Avascular necrosis

Table 1 (continued)

References	Study design	Patients		Mean age (range)		Gender (male/female)		Interventions	Study period	Follow-up (months)	Main outcomes
		SHS	Cancellous screws	SHS	Cancellous screws	SHS	Cancellous screws				
Paus et al. [25]	RCT	66	65	69	69	24/107	24/107	SHS versus two von Bahr screws	-	28 months	Nonunion, avascular necrosis, deep reoperations, deep wound infection

SHS sliding hip screws, DHS dynamic hip screws, RCT randomized clinical trial

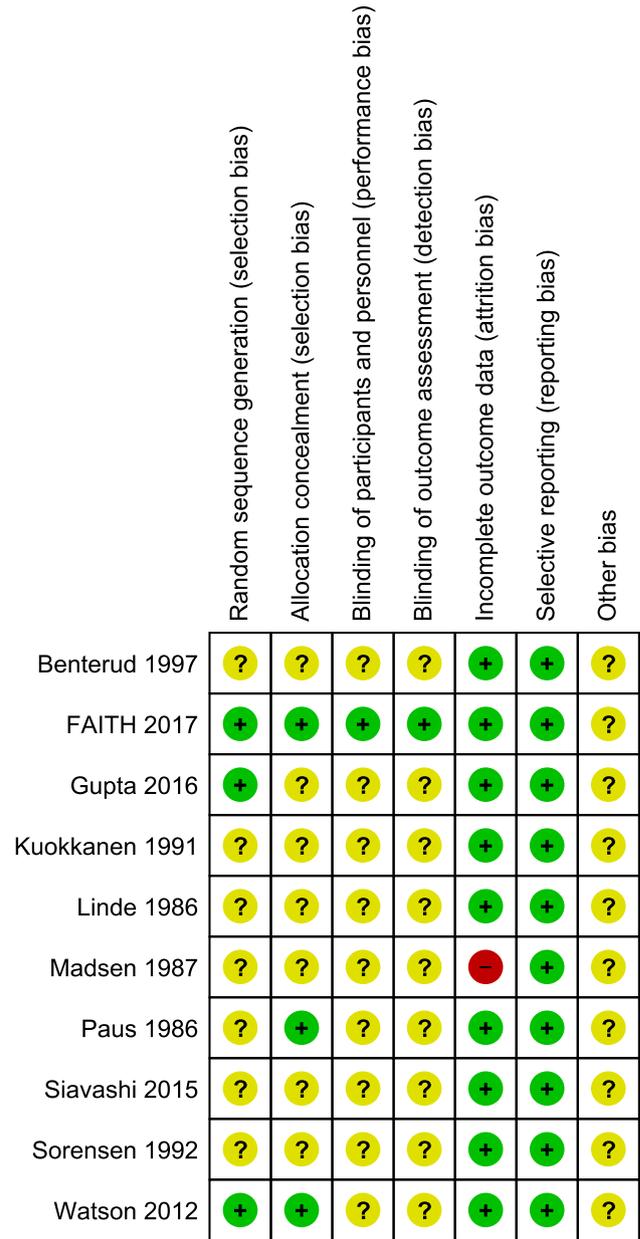


Fig. 2 Risk of bias summary of randomized clinical trials

terms of postoperative mortality (RR = 1.03, 95% CI [0.71, 1.51], $p = 0.86$, Fig. 8).

Subgroup analysis by the type of cancellous screws

Subgroup analysis by the type of cancellous screws was consistent with the results of the overall pooled estimate, except for fracture healing in which three Gouffon screws had higher risk than sliding hip screws (RR = 0.52, 95% CI [0.31, 0.87], Fig. 4e).

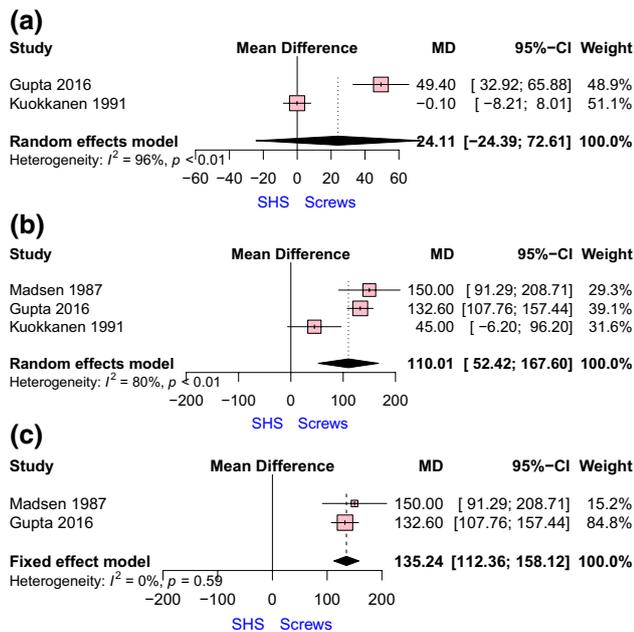


Fig. 3 **a** Forest plot of mean difference (MD) in operative duration with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws. **b** Forest plot of mean difference (MD) in intraoperative blood loss with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws. **c** Forest plot of sensitivity analysis of mean difference (MD) in intraoperative blood loss with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws

Discussion

Our study results revealed no significant difference between SHS and cancellous screws in terms of operative time, postoperative hip function, nonunion, avascular necrosis, reoperation rate, infection, fracture healing, hip pain, medical complications, and mortality rate. Only intraoperative blood loss was greater in the SHS patients.

Patients with intracapsular femoral neck fractures present frequently to the emergency department, yet despite this, the management approach can be controversial and can vary between centers and clinicians [29]. Most frequently these can be categorized into three procedures: total arthroplasty, hemiarthroplasty or open reduction, and internal fixation. Femoral neck fractures can be categorized according to Garden's classification into type I, II, III, IV or can be more simply into undisplaced (type I and II) or displaced (type III and IV).

There is strong evidence presented by multiple studies [30, 31] and recommended by the American Academy of Orthopedic Surgeons (AAOS) [32] that the less active older patients (especially above 80 years old) with displaced femoral neck fractures should be treated with total hip arthroplasty or hemiarthroplasty as these provide the

most reliable outcomes [33]. Internal fixation is often considered a better option for undisplaced fractures [32, 34] and may be indicated in displaced fractures for younger active adults. It is less invasive and more affordable, provides the possibility of maintaining the native femoral head and improving function, and delays the need for future arthroplasty [30, 34]. However, internal fixation does require a longer period of postoperative monitoring for complications, such as avascular necrosis, with or without a period of protected weight bearing. Internal fixation can be achieved by SHS or cancellous screws, and determining which procedure is better depends on the rate of reoperation and the incidence of complications.

We included multiple outcomes to try to conclude which approach is more reliable. These outcomes were duration of surgery, intraoperative blood loss, nonunion, avascular necrosis, reoperation rate, infection, fracture healing, hip function scores, medical outcomes, hip pain, and mortality. Our meta-analysis demonstrated that cancellous screws were superior in terms of intraoperative blood loss, but there were no other significant differences. A previous systematic review confirmed our results that cancellous screws are associated with less blood loss [35].

Our findings were consistent with the current trend of using cancellous screws in management of undisplaced femoral neck fractures [36]. However, one of the limitations of our study is the inability to isolate the results of displaced and undisplaced fractures due to lack of such segregation in the included studies. On the other hand, the FAITH study [20] managed to prove, with subgroup analysis, that SHS group is superior to cancellous screws group in management of displaced fractures, basal fractures, and fractures in smokers thanks to a greater biomechanical stability of SHS.

A recently published meta-analysis compared SHS to cancellous screws [37] and established the same result of nonexistence of significant difference in the rate of postoperative complication in spite of the trend that claims cancellous screws to have a higher complications rate, especially avascular necrosis [35]. We tried to overcome the limitations of that meta-analysis by inclusion of additional studies and exclusion of the Targon femoral neck system in management of femoral neck fractures to be more focused on SHS and cancellous screws.

Stockton et al. [38] described the failure patterns of femoral neck fracture fixation in patients aged 18–55 years and emphasized, in agreement of our study, that both SHS and multiple cannulated screws were similar in the postoperative failure rate. However, SHS was associated more with screw cutout due to failure of the cancellous trabeculae to resist the rotation of the femoral head around the lag screw [39]. While, multiple cancellous screws failed by varus collapse [38]. This in turn leads to the evolution

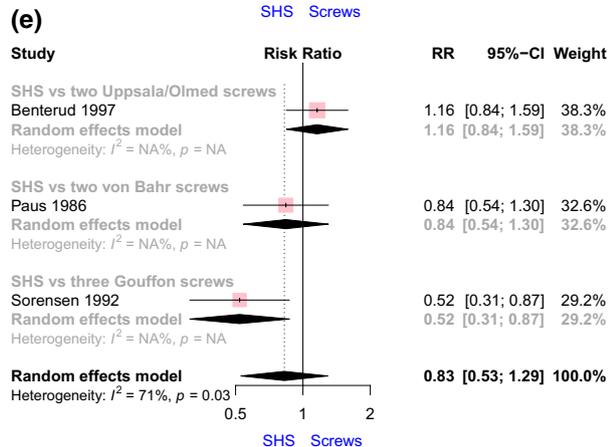
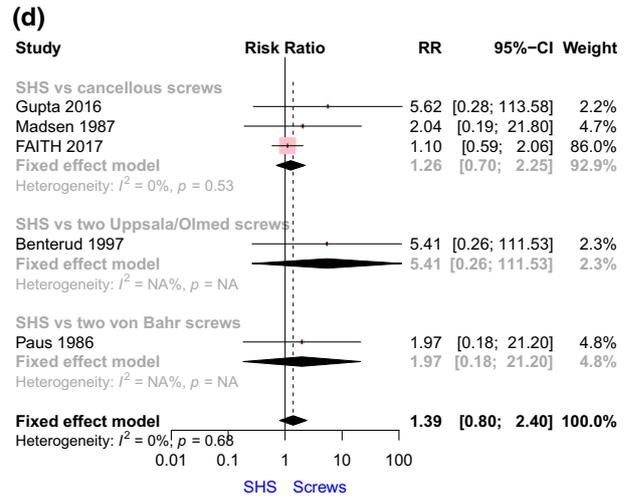
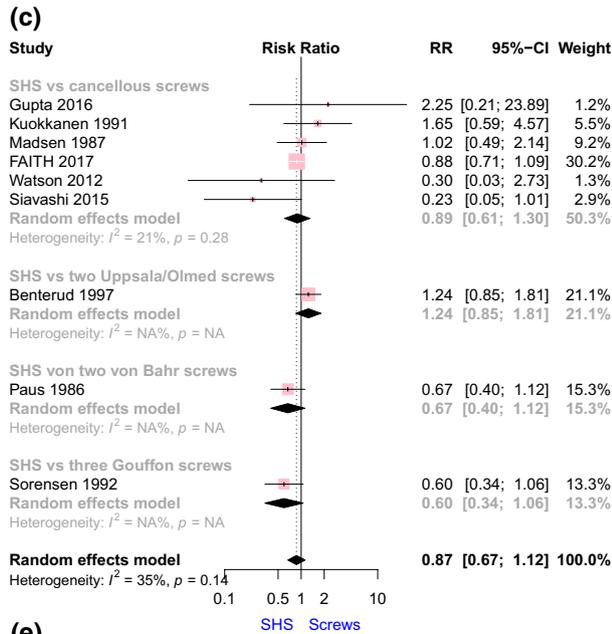
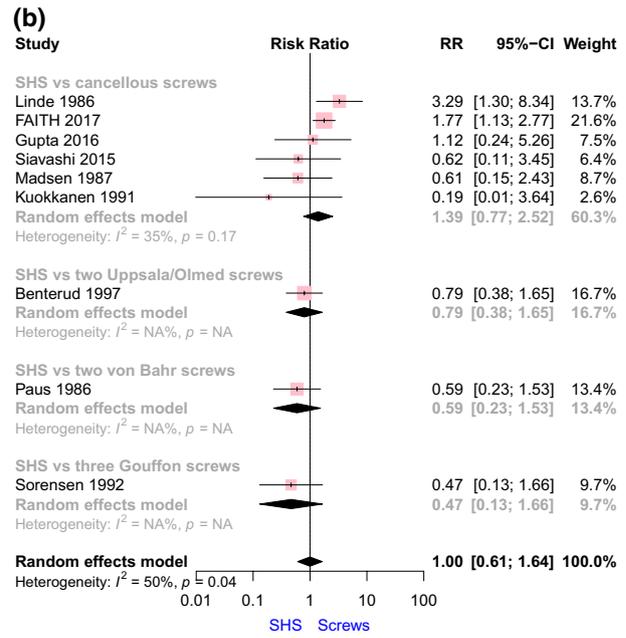
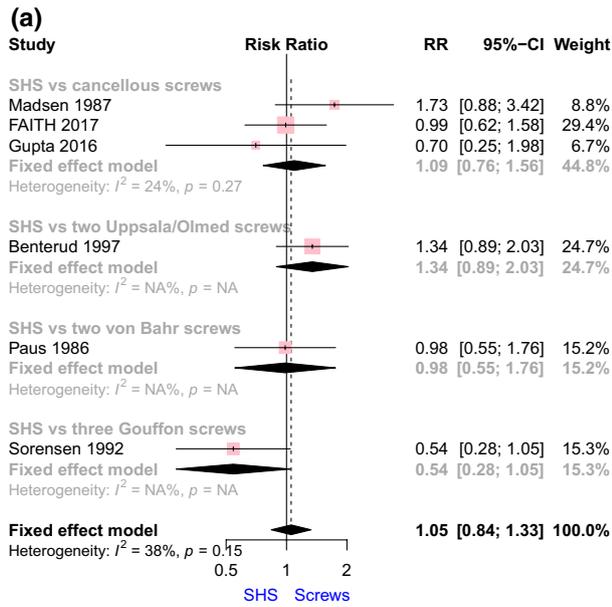


Fig. 4 a Forest plot of risk ratio (RR) of nonunion with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws. **b** Forest plot of risk ratio (RR) of avascular necrosis with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws. **c** Forest plot of risk ratio (RR) of reoperation rate with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws. **d** Forest Plot of risk ratio (RR) of infection with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws. **e** Forest Plot of risk ratio (RR) of fracture healing with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws

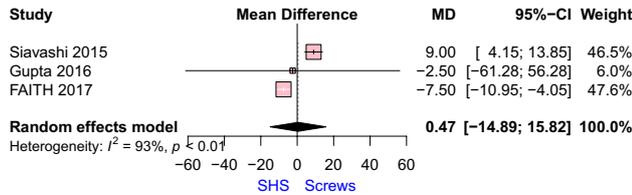


Fig. 5 Forest Plot of mean difference (MD) in hip function score with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws

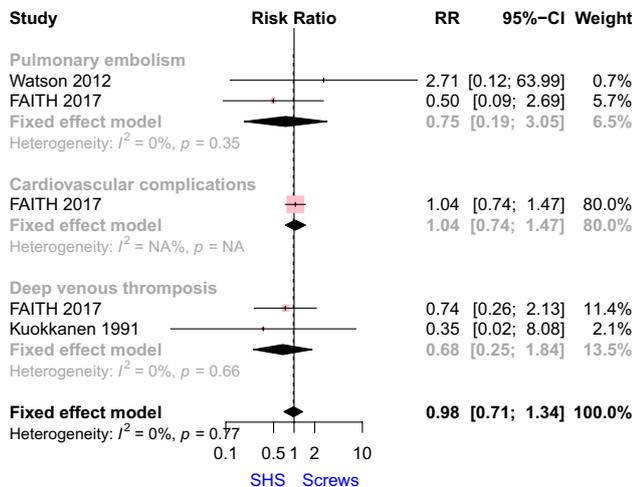


Fig. 6 Forest Plot of risk ratio (RR) of medical outcomes with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws

of new implants that overcome these failure patterns, such as the dynamic locking blade plate which was tried by Kalsbeek et al. [39]. The authors reported that this plate possesses the advantages of dynamic compression, angular and rotational stability, and low implant volume within the femoral head with only 13.2% postoperative failure rate.

Contrarily to our study, some authors recommended the use of arthroplasty starting from age of 55 years owing to the higher reoperation rate (27%) following internal

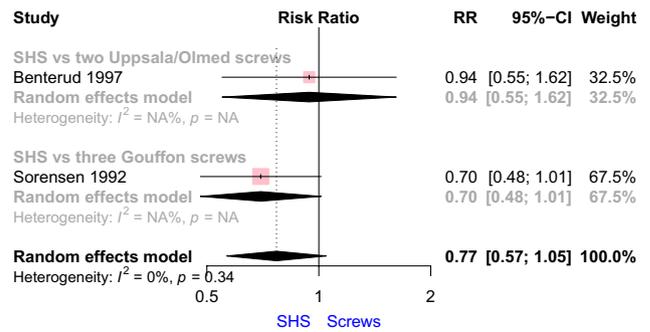


Fig. 7 Forest Plot of risk ratio (RR) of hip pain with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws

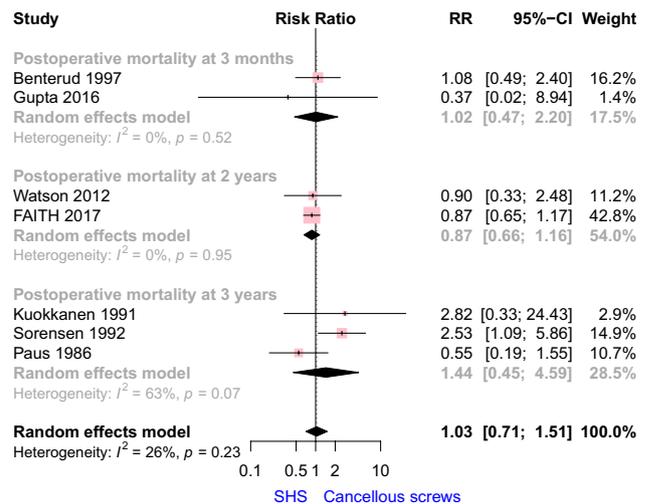


Fig. 8 Forest Plot of risk ratio (RR) of mortality with 95% confidence interval, comparing between sliding hip screws (SHS) and cancellous screws

fixation [40]. This is in agreement with Stockton et al. [41] who observed that one in three patients required a reoperation and one in seven patients was converted to total hip arthroplasty.

Limitations of the study

Absence of a unified method of reduction in included studies may affect the incidence of postoperative complications, particularly the rate of surgical site infection, which may be lower in closed reduction than in open reduction [42]. Other potential confounders to the outcomes of surgical intervention include inseparable age-groups, fracture levels, and difference in Pauwels' classification. The lack of blinding of the included trials may also be a confounding factor. Tests for funnel plot asymmetry and

meta-regression could not be used as there are a small number of studies included in the meta-analysis.

Future directions

Screws are expedient in maintaining the fracture reduction, while the SHS can better resist the shear forces and varus collapse [43]. Therefore, new generations of implants that combine the biomechanical advantages of both modalities may be investigated. Additionally, future researches should focus on enhancing the vascularity of this critical area by the use of either pedicled or free vascularized grafts or encouraging the healing potential by the use of bone morphogenic proteins.

Conclusion

This review gives us better understanding of the available evidence regarding a commonly encountered orthopedic problem. The cancellous screws group had less intraoperative blood loss than the SHS group. No difference could be detected between the two treatment modalities regarding the operative time, postoperative hip function, nonunion, avascular necrosis, reoperation rate, infection, fracture healing, hip pain, medical complications, and mortality rate.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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