Am J Transl Res 2022;14(8):5480-5490
www.ajtr.org /ISSN:1943-8141/AJTR0142993

Original Article

Femoral neck system versus cannulated screws for fixation of femoral neck fracture in young adults: a systematic review and meta-analysis

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Received March 20, 2022; Accepted July 6, 2022; Epub August 15, 2022; Published August 30, 2022

Abstract: Purpose: Femoral neck fracture treatment in young adults remains controversial. Cannulated screws (CS) and femoral neck system (FNS) are well-accepted methods for femoral neck fracture treatment; however, these methods are associated with complications. This meta-analysis aimed to evaluate the relative safety and effectiveness of CS and FNS for treating young patients with femoral neck fractures. Methods: We searched the following sources for studies that compared CS and FNS fixation: Cochrane library, Embase, PubMed, Web of Science, Wanfang data, China National Knowledge Infrastructure, China Biology Medicine disc, and Chinese Science and Technology Journals. The outcomes were surgical and prognostic results and complications. Results: This meta-analysis included eight studies. The pooled results revealed that the two fixation methods were similar in terms of the operation time, length of hospital stay, healing time, intraoperative blood loss, non-union, femoral head necrosis, and internal fixation cut-out. Compared with CS fixation, FNS fixation required fewer intraoperative fluoroscopies and had better Harris Hip Score, earlier weight-bearing, lower number of total complications, lesser femoral neck shortening, and lesser extent of nail retreat. Conclusion: FNS fixation outperforms CS fixation in terms of intraoperative fluoroscopies, Harris Hip Score, and morbidity in young patients with femoral neck fractures. Clinicians should consider FNS as a first choice in treating femoral neck fracture in young adults, except where this approach is contraindicated.

Keywords: Young adults, femoral neck fracture, cannulated screws, femoral neck system

Introduction

Femoral neck fracture is a common fracture in orthopedic trauma, accounting for approximately 3.6% of human fractures and 54.0% of hip fractures [1]. Femoral neck fracture in young adults accounts for 2.0-3.0% of all femoral neck fractures, and are mostly caused by high-energy injuries [2]. Femoral neck fracture treatment in young adults remains controversial. Cannulated screws (CS) and femoral neck system (FNS) are well-accepted methods for femoral neck fracture treatment; however, both methods are associated with complications [3-6]. Currently, the multiple CS method is the standard of care for younger patients, as this approach is less invasive and preserves blood supply in comparison with FNS. CS occupy only a small amount of space in the femoral neck and head, which can reduce interference to the femoral head and femoral head and neck blood flow [3]. Three screws should be inserted in parallel to each other in an inverted triangle configuration in the CS fixation, to form a stable spatial arrangement and avoid rotation [3]. The CS approach can reduce compressive stress between fracture ends and induce intimate contact between them, encouraging fracture healing [3]. However, previous studies have reported that CS is associated with early complications, such as fracture shortening, nonunion, and implant failure [4, 5]. The femoral neck system (FNS) is a novel fixation modality

used to treat femoral neck fractures [6]. Biomechanical studies suggest that the FNS can provide greater biomechanical stability for femoral neck fracture, particularly in unstable and displaced fractures [6, 7]. Our previous clinical investigation with FNS fixation similarly yielded positive results [8]. However, there is continuing uncertainty among orthopedic surgeons regarding the best treatment for a femoral neck fracture. Furthermore, it is necessary to evaluate the safety and feasibility of any emerging fixation technology. Therefore, this meta-analysis was conducted to compare the outcomes of CS and FNS in the treatment of femoral neck fracture in young adults. Our results will provide evidence to guide clinicians in selecting the most appropriate fixation method for femoral neck fracture treatment in young adults.

Materials and methods

Search strategy

The Cochrane Library, Embase, PubMed, Web of Science, Wanfang data, China National Knowledge Infrastructure, China Biology Medicine disc, and Chinese Science and Technology Journals were searched without language restrictions from the inception of each database up to March 15, 2022. Keywords included: 1) "femoral neck system" and "FNS"; 2) "cannulated screws", "cannulate compression screw", "CCS", and "CS"; and 3) "femoral neck fracture" and "FNF". The search strategy is provided in Tables S1, S2, S3, S4. Articles were screened independently by two investigators, according to the eligibility criteria [9]. Review articles were screened for relevant referenced articles.

Eligibility criteria

Inclusion criteria: 1) *patients*: adults (aged between 18 and 65 years) diagnosed with unilateral femoral neck fracture for the first time; 2) *intervention*: experimental group with FNS fixation; 3) c*omparison:* control group with fixation by CS; 4) *outcomes*: at least one outcome measure from: operation time (minutes), intraoperative blood loss (mL), intraoperative fluoroscopies, hospital stay (days), weight-bearing time (months), healing time (months), Harris Hip Score [10], or postoperative complications; and 5) *study design:* prospective cohort studies (PCS), retrospective comparative control trials (CCT), and randomized controlled trials (RCT).

Exclusion criteria: 1) review articles, conference summary, comments, and biomechanical studies; and 2) patients with a pathological or open femoral neck fracture.

Data extraction and quality assessment

Two investigators independently extracted the data from identified articles following a standardized form. Data extraction included: first author, year of publication, study type, basic characteristics of the study participants (sample size, age, gender, etc.), femoral neck fracture-related information (affected side, Garden classification, Pauwels type, cause of fracture, and time of injury to surgery), intervention group, follow-up time, and outcome indicators. If there were data extraction inconsistencies between the investigators, a consensus was established through discussion. The risk of bias was evaluated using ROBINS-I for non-randomized clinical studies [11], and the Cochrane Collaboration Risk of Bias tool for RCT trials [12].

Statistical analysis

RevMan v5.3 (The Cochrane Collaboration) and Stata v12.0 (StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP) software were used to analyze the data. Risk ratio (RR) and weighted mean difference (WMD) with 95% confidence intervals (CI) were utilized to evaluate categorical and continuous variables, respectively. Cochran's Q and I^2 tests were employed to determine heterogeneity [13]. A random-effects model was used when I^2>50% or the Q statistic *p*-value was <0.05; otherwise, a fixed-effects model was used. The Egger test was used to investigate publication bias [13].

Results

Search results

Figure 1 depicts the flow chart of article selection. A total of 363 records were retrieved through electronic databases. After excluding duplicates, 212 articles remained in the sam-

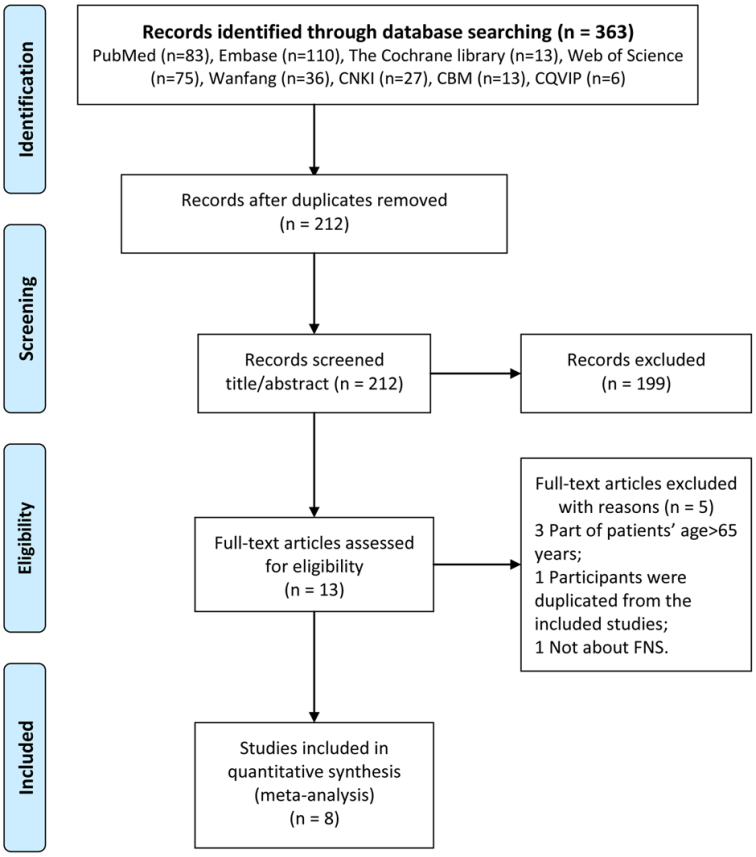

Figure 1. Flow diagram of literature search and study selection. CBM, China Biology Medicine disc; CNKI, China National Knowledge Infrastructure; CQVIP, China Science, and technology journal database.

ple; 199 studies were excluded as they did not meet the inclusion criteria. After full-text screening, eight studies [8, 14-20] were included.

Study characteristics and quality assessment

The eight included studies were all retrospective cohort studies; they involved 522 patients, with study sample sizes ranging from 34-94 patients (**Table 1**). The FNS group contained 234 patients (129 males and 105 females), and the CS group contained 288 patients (164 males and 124 females). There were no significant differences between the two groups in regard to age [8, 14-20], sex [8, 14-20], affected side [17, 19, 20], Garden classification [8, 14, 16-18], Pauwels type [14, 15, 18, 19], time from fracture to treatment [15-17, 19, 20], or cause of fracture [8, 17-20]. The follow-up time [8, 14-17, 19, 20] of the included studies was between 6 and 24 months. The included studies have a low to moderate risk of bias (**Table 2**).

Meta-analyses

Surgical results

Operation time: Eight studies [8, 14-20] reported operative time for two fixation methods. No difference was found between the FNS and CS groups [WMD = -7.26, 95% CI = [-15.54, 1.02], P = 0.09, I^2 = 93%) (**Figure 2A**).

Intraoperative blood loss: Six studies [14, 15, 17-20] compared intraoperative blood loss between the two methods. The intraoperative blood loss was lesser in the CS group compared with that in the FNS group (WMD = 22.46; 95% CI = [1.70, 43.22]; P = 0.03; I^2 = 92%) (**Figure 2B**).

Intraoperative fluoroscopies: Two studies [8, 20] reported intraoperative fluoroscopies. Pooled results indicated that intraoperative fluoroscopies were used less in the FNS group than in the CS group (WMD = -8.19; 95% CI = [-9.45, -6.93], P<0.00001; I^2 = 48%) (**Figure 2C**).

Prognostic results

According to pooled results, there was no significant difference between the FNS and CS groups in length of hospital stay (**Figure 3A**), weight-bearing time (**Figure 3B**) and healing time (**Figure 3C**).

Harris hip score: Eight studies [8, 14-20] reported the Harris Hip Score for 522 hips (288 for CCS and 234 for FNS), with follow-up periods of 3-24 months. Analysis of the pooled data revealed that the FNS group had higher Harris Hip Scores than the CS group (WMD = 4.08; 95% CI = [1.77, 6.40]; P = 0.0005; I^2 = 88%) (**Figure 3D**).

Complications

Total complications: Five studies [8, 14, 15, 17, 18] reported total complications for 325 hips

Table 1. Characteristics of 8 included studies

Study	Group	n, M/F	Left/Right	Age, years	Garden classification (I/II/III/IV)	Pauwels type (I/II/III)	Cause of injury, Slide/ TA/FFH	From injury to surgery, days	Follow up, months	Outcomes
He, CJ 2021 [8]	FNS	33, 18/15	NR	50.61±10.30	1/8/19/5	NR	21/12/0	NR	16.91±3.01	a, c, d, f, g, h, i, j, l, m
	CS	36, 22/14	NR	47.58±10.31	2/9/20/5	NR	25/11/0	NR		
Hu, HJ 2021 [14]	FNS	20, 12/8	NR	50.45±8.45	0/6/8/6	1/14/5	NR	NR	≥12	a, b, f, g, h, i, j, k, l
	CS	24, 14/10	NR	50.46±9.26	4/6/7/7	4/13/7	NR	NR		
Ren, C 2021 [17]	FNS	32, 16/16	13/19	49.4±11.0	0/10/12/10	NR	22/10/0	4.3±2.4	11.5±2.9	a, b, e, f, g, h, j, k, m
	CS	38, 19/19	13/25	48.8±10.1	0/12/15/11	NR	27/11/0	4.2±2.3	11.7±3.4	
Yan, CP 2021 [18]	FNS	24, 10/14	NR	52 (47, 63)	0/4/12/8	0/6/18	14/6/4	NR	7.3 (3-12)	a, b, g, h, i, j, k
	CS	58, 38/20	NR	49 (47, 56)	2/10/32/14	0/22/36	36/6/16	NR	13.6 (6-18)*	
Yang, JZ 2021 [19]	FNS	47, 30/17	30/17	47.8±9.8	NR	3/16/28	17/21/9	4.0 (3.0, 5.0)	11.1±3.3	a, b, d, e, f, g, k, l
	CS	47, 26/21	22/25	43.7±13.1	NR	6/20/21	15/18/14	4.0 (3.0, 5.0)	11.4±2.6	
Yang, YJ 2021 [20]	FNS	15, 9/6	9/6	40.2 (19-64)	1/3/10/1	NR	4/6/5	1.11 (0.38-1.96)	6	a, b, c, f, g, i, j, k, l
	CS	19, 12/7	12/7	41.2 (22-63)	2/4/11/2	NR	4/9/6	1.07 (0.38-1.92)		
Zhang, YZ 2022 [16]	FNS	33, 22/11	NR	57.61±11.87	0/10/9/14	NR	NR	1.79±0.86	≥6	a, d, g, j, m
	CS	36, 21/15	NR	52.50±10.72	0/12/14/10	NR	NR	1.56±0.73		
Zhou, XQ 2021 [15]	FNS	30, 12/18	NR	54.53±6.71	NR	0/0/30	NR	≤2	10-22	a, b, d, g, h, j, k, l
	CS	30, 12/18	NR	53.14±7.19	NR	0/0/30	NR	≤2	10-22	

CS, cannulated screw; F, female; FNS, femoral neck system; M, male; NR, not reported; TA, traffic accident; FFH, Fall from Height; *, P<0.05. Outcomes: a, Operation duration; b, Intraoperative blood loss; c, Intraoperative fluoroscopies; d, Hospital stay; e, Weight-bearing time; f, Healing time; g, Harris Hip Score; h, Total Complications; i, Nonunion of bone; j, Femoral neck shortening; k, Femoral head necrosis; l, Internal fixation cutout; m, Nail retreat.

Table 2. Quality assessment of the clinical controlled studies

Study	Bias due to confounding	Bias in the selection of participants into the study	Bias in the classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in the measurement of outcomes	Bias in the selection of the reported result
He, CJ 2021 [8]	Moderate	Low	Low	Low	Low	Low	Low
Hu, HJ 2021 [14]	Moderate	Low	Low	Low	Low	Low	Low
Ren, C 2021 [17]	Low	Low	Low	Low	Low	Low	Low
Yan, CP 2021 [18]	Moderate	Moderate	Low	Low	Low	Low	Moderate
Yang, JZ 2021 [19]	Low	Low	Low	Low	Low	Low	Moderate
Yang, YJ 2021 [20]	Low	Low	Low	Low	Low	Low	Moderate
Zhang, YZ 2022 [16]	Moderate	Low	Low	Low	Low	Low	Low
Zhou, XQ 2021 [15]	Moderate	Low	Low	Low	Low	Low	Moderate

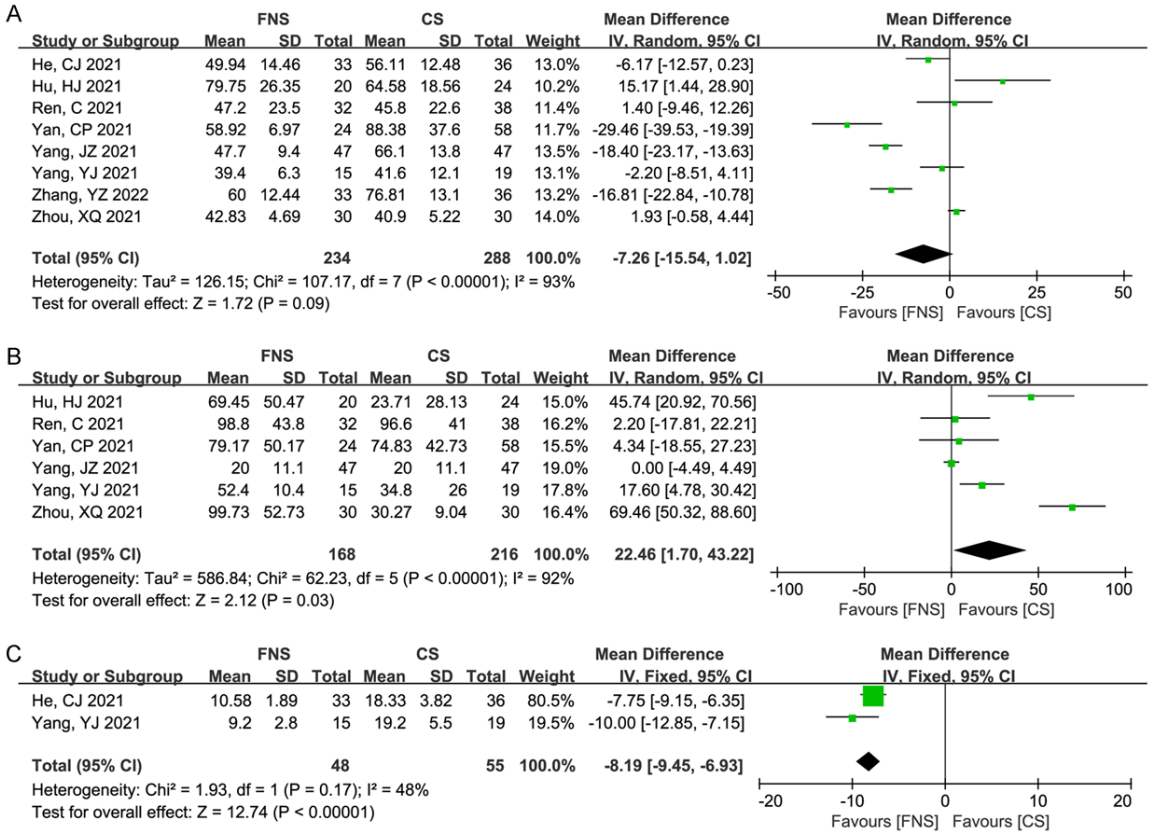

Figure 2. Forest plot comparisons for Operation time (A), Intraoperative blood loss (B), and Intraoperative fluoroscopies (C). CS, cannulated screw; FNS, femoral neck system.

(186 for CS and 139 for FNS), with follow-up periods of 3-24 months. Total complication rates for the FNS and CS methods were 10.8% (15/139) and 36.5% (68/186), respectively, which were significantly different statistically (RR = 0.29; 95% CI = [0.18, 0.48], P<0.00001, I^2 = 0%) (**Figure 4A**).

Femoral neck shortening: Seven studies [8, 14-18, 20] reported the femoral neck shortening for 428 hips (241 for CS and 187 for FNS), with follow-up periods of 3-24 months. The rates of femoral neck shortening of the FNS and CS methods were 6.4% (12/187) and 17.0% (41/241), respectively, which were sig-

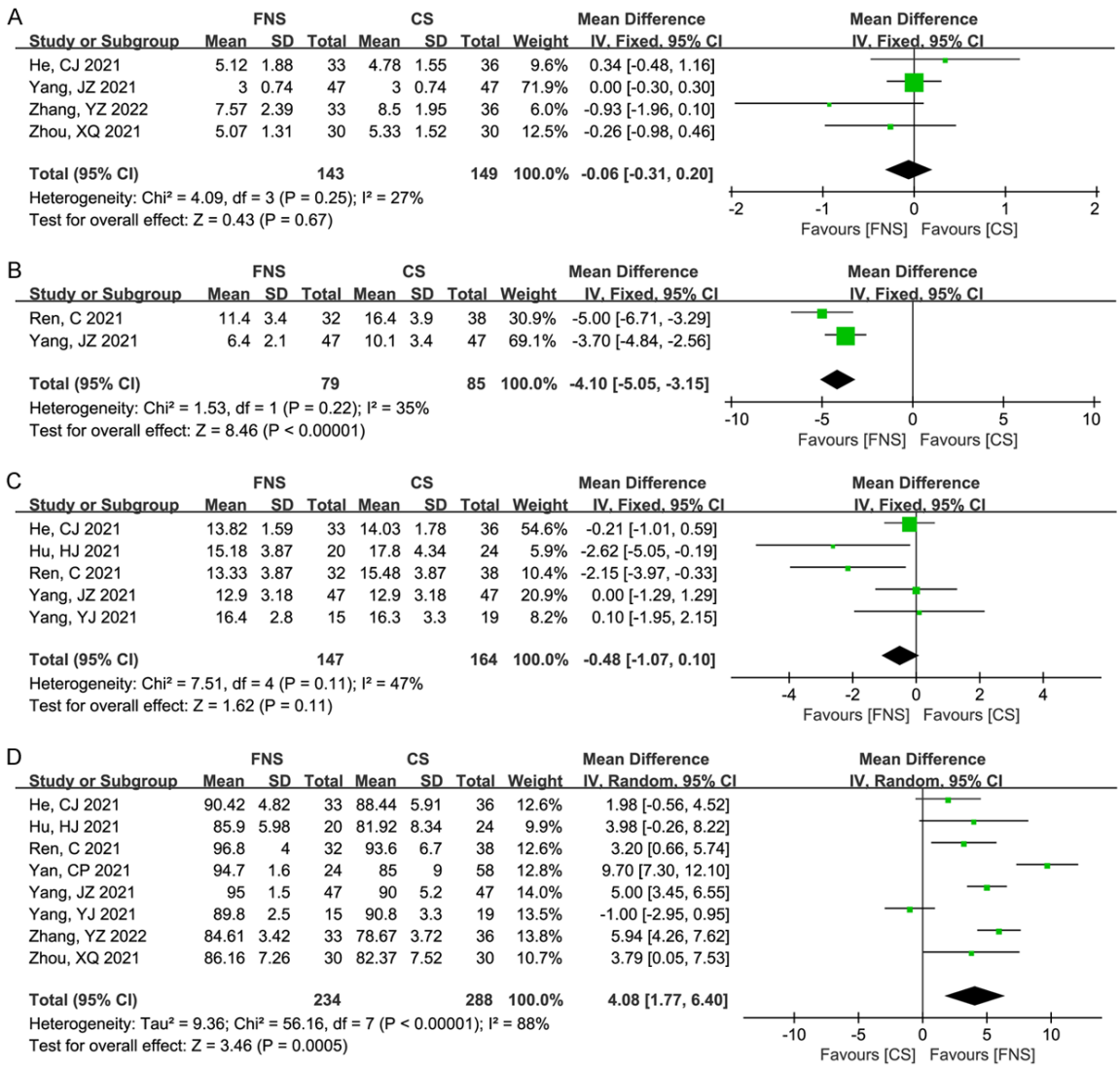

Figure 3. Forest plot comparisons for prognostic outcomes. A. Length of hospital stay. B. weight-bearing time. C. Healing time. D. Harris Hip Score. CS, cannulated screw; FNS, femoral neck system.

nificantly different (RR = 0.44, 95% CI = [0.24, 0.81], $P = 0.009$, $I^2 = 0\%$) (**Figure 4B**).

According to pooled results, there was no significant difference between the FNS and CS groups in non-union (**Figure 5A**), femoral head necrosis (**Figure 5B**), internal fixation cut-out (**Figure 5C**) and nail retreat (**Figure 5D**).

Results of sensitivity analyses and reporting bias

The results of the sensitivity analyses suggested that the meta-analyses of the operation time, intraoperative blood loss, and nail retreat were unstable (**Table 3**). The pooled outcomes of the remaining outcome measures were stable. There was no significant publication bias in the included studies for all indicators (Egger's test, $P>0.05$) (**Table 3**).

Discussion

This meta-analysis compared the clinical outcomes of FNS and CS fixation for femoral neck fracture in young adults. The study found that FNS is superior to CS in terms of intraoperative fluoroscopies, weight-bearing time, Harris Hip Score, total complications, femoral neck shortening, and nail retreat. However, the two fixation methods were similar in terms of the oper-

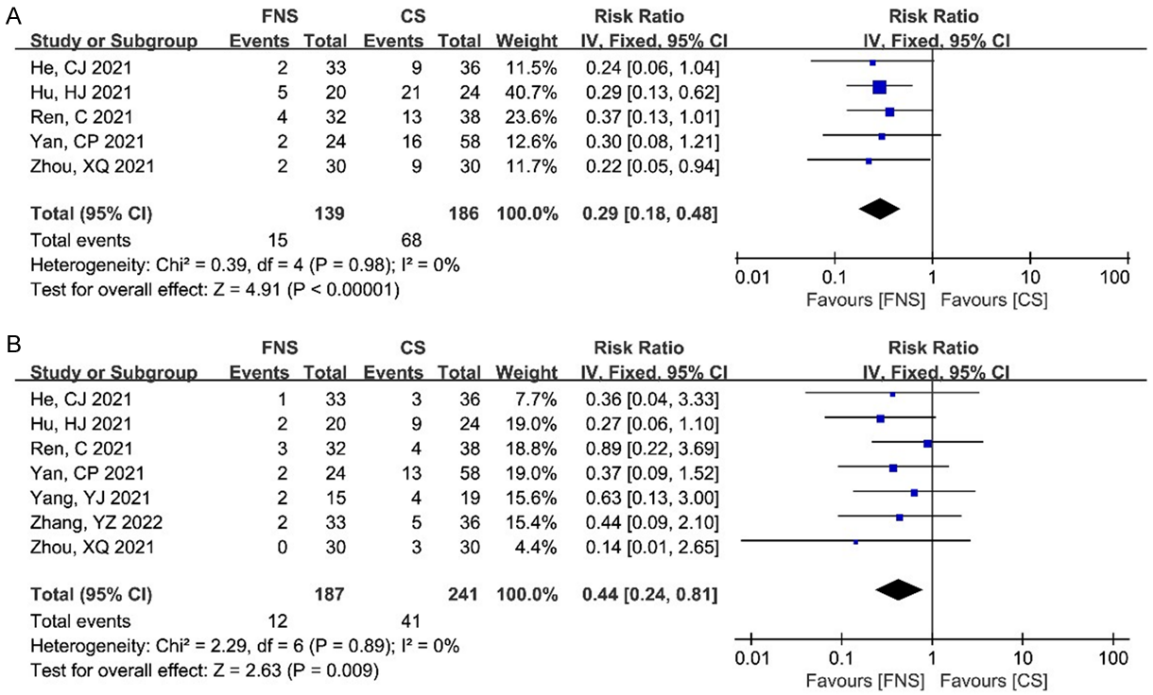

Figure 4. Forest plot comparisons for complications. A. Total complications. B. Femoral neck shortening. CS, cannulated screw; FNS, femoral neck system.

ation time, length of hospital stay, healing time, intraoperative blood loss, non-union, femoral head necrosis, and internal fixation cut-out. From the perspective of surgical outcomes, intraoperative fluoroscopies were used less in FNS fixation than in CS fixation. Three screws should be inserted in parallel to each other in an inverted triangle configuration in the CS fixation method [3]. Therefore, the position of the guide wires needs to be adjusted repeatedly to ensure a parallel alignment. However, too many adjustments will increase the number of intraoperative fluoroscopies, which can increase exposure to x-ray radiation patients and orthopedic surgeons, which can have an adverse effect on health [21]. The FNS is comprised of a central bolt, anti-rotation screw, and plate, and can be successfully performed when a guidewire is inserted for biplanar central position through the femoral neck and head, requiring fewer intraoperative fluoroscopies [22].

In our metanalysis, intraoperative blood loss was lower in the CS group than in the FNS method group. The incision length is an important factor that can affect intraoperative blood loss [23]. For the FNS method, an incision of approximately 4 cm is needed so that a small plate can be inserted [22]. However, the CS is a relatively less invasive technique, with a mean incision length of only 2.7 cm [24].

The operative time in the FNS group was not significantly different from that in the CS group. Our previous study reported that the mean operation time was 49.94 ± 14.46 min and 56.11 ± 12.48 min in the FNS and CS groups, respectively [7]; the difference was not statistically significant. While Ma reported that incision length and blood loss can affect the length of hospital stay [23], we found no significant difference between the FNS and CS groups for the length of hospital stay.

The Harris Hip Score is one of the outcome markers for measuring hip function that is linked to patient prognosis. We found that the Harris Hip Score for FNS fixation was higher than that for CS fixation. Both Tang [25] and Xiong et al. [26] have previously reported that the mean Harris hip score for FNS fixation was much greater than that for CS fixation. It could be argued that weight-bearing time is an important factor that can affect the Harris Hip Score. Our pooled data analysis showed that

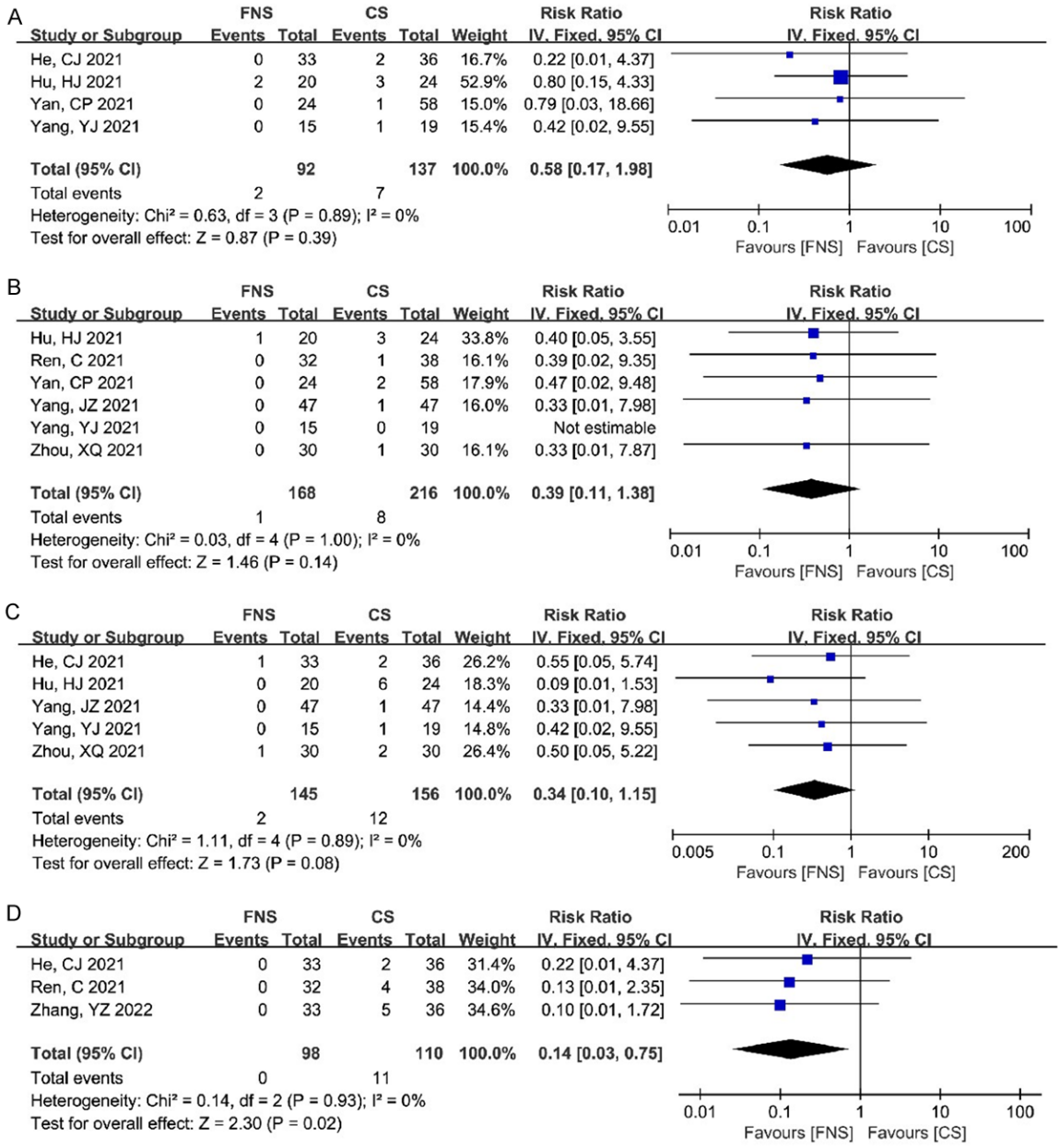

Figure 5. Forest plot comparisons for complications. A. Non-union. B. Femoral head necrosis. C. Internal fixation cut-out. D. Nail retreat. CS, cannulated screw; FNS, femoral neck system.

the weight-bearing time of the FNS fixation group was significantly less than that of the CS fixation group. Furthermore, the mean healing time was an important indicator of surgery efficacy and safety. Tang et al. [25] found that the mean healing time in the CS fixation group was longer than in the FNS fixation group. However, another study found no significant difference in healing time between the two groups in the treatment of femoral neck fracture in adults [27]. Our meta-analysis results were similar to those of Wang et al. [27], with no significant difference in healing time between the two groups.

Postoperative complications were an important indicator of the safety of both fixation methods. This meta-analysis revealed that the rate of total complications for FNS was higher than that for CS. For the non-union and internal fixation cut-out, we found that the FNS group was not better than the CS group, which was consistent with a previous study [28]. This study

Table 3. Outcomes of the sensitivity analysis and test of publication bias

Outcomes	No. of studies	Sensitivity analysis	Egger's test	
		WMDs/RRs (95% CI)	Robust	*P* value
Operation duration, minutes	8	-9.80 (-18.38, -1.22) to -4.44 (-12.49, 3.61)	No	0.360
Perioperative blood loss, mL	6	12.00 (-1.87, 25.87) to 27.73 (3.16, 52.31)	No	0.128
Intraoperative fluoroscopies	2	-10.00 (-12.85, -7.15) to -7.75 (-9.15, -6.35)	Yes	NA
Hospital stay, days	4	-0.20 (-0.68, 0.28) to 0.00 (-0.26, 0.26)	Yes	0.534
Weight-bearing time, weeks	2	-5.00 (-6.71, -3.29) to -3.70 (-4.84, -2.56)	Yes	NA
Healing time, weeks	5	-0.81 (-1.69, 0.06) to -0.29 (-0.91, 0.33)	Yes	0.257
Harris Hip Score	8	3.26 (1.18, 5.34) to 4.94 (3.12, 6.75)	Yes	0.862
Total Complications	5	0.27 (0.15, 0.48) to 0.30 (0.18, 0.51)#	Yes	0.481
Non-union of bone	4	0.41 (0.07, 2.42) to 0.71 (0.18, 2.71)#	Yes	0.366
Femoral neck shortening	7	0.37 (0.19, 0.74) to 0.49 (0.25, 0.98)#	Yes	0.302
Femoral head necrosis	6	0.37 (0.09, 1.51) to 0.40 (0.10, 1.60)#	Yes	0.621
Internal fixation cutout	5	0.29 (0.07, 1.19) to 0.46 (0.12, 1.76)#	Yes	0.489
Nail retreat	3	0.11 (0.01, 0.87) to 0.17 (0.02, 1.34)#	No	0.118

RRs, Risk Ratios; WMD; weighted mean difference; #, RR (95% CI); NA, Not available.

showed no significant difference in femoral head necrosis between the two treatments. A previous study reported a femoral head necrosis rate of 6.3% in an FNS group [22]. Hoshino et al. [29] reported that the femoral head necrosis rate for CS was 33%. We found that the incidence of femoral neck shortening was less in the FNS group (6.4%) than in the CS group (17.0%). While previous studies have reported that the rate of femoral neck shortening ranged from 29 to 50.6% in the CS group [3, 30], more recent studies have reported femoral neck shortening rates ranging from 0-19% for FNS fixation [14, 31]. Finite element analysis and biomechanical study confirmed that FNS provides increased stability compared with CS for femoral neck fracture treatment [5, 6, 32]. The FNS has a 20-mm sliding compression space which can provide the direction of sliding pressure after reduction; thus, mitigating femoral neck shortening [33]. CS fixation does not have this advantage, and the nail will retreat when shortening of the femoral neck occurs. The analysis of the pooled data found that the nail retreat rate of the FNS group was significantly less than that of the CS group.

Our study had some limitations: (1) Complete baseline information was not reported in some included studies, and there was lack of information about the surgical team, which may cause clinical heterogeneity. There was statistically significant heterogeneity in the continuous variables, such as operative time and intraoperative bleeding loss, which may affect analysis outcomes; (2) Despite the significant heterogeneity in this study, the number of included studies for some indicators was small, such as sex, age, Garden classification, Pauwels type, and follow-up time. Thus, subgroup analysis could not be performed to clarify the cause of heterogeneity and bias; and (3) The combined results of some outcome measures were unstable, and more high-quality, large-sample RCTs are needed to verify the differences between FNS and CS in some intraoperative and prognostic outcomes.

In conclusion, FNS fixation has advantages in intraoperative surgery, prognostic efficacy, and lack of complications compared with CS fixation for femoral neck fractures. There was some heterogeneity in the pooled results, so we suggest that large, high-quality RCTs are required to adequately compare the two fixation methods for young patients with femoral neck fractures.

Disclosure of conflict of interest

None.

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Table S1. The search strategy and results of PubMed

Search	Query	Items found
#1	("FNS"[All Fields] OR (("femur neck"[MeSH Terms] OR "femur neck"[All Fields] OR "femoral neck"[All Fields]) AND ("system"[All Fields] OR "systems"[All Fields])))	3183
#2	(("cannulate"[All Fields] OR "cannulated"[All Fields] OR "cannulating"[All Fields] OR "cannulator"[All Fields] OR "cannulators"[All Fields] OR "cannulisation"[All Fields] OR "cannulization"[All Fields] OR "cannulized"[All Fields] OR "catheterization"[MeSH Terms] OR "catheterization"[All Fields] OR "cannulation"[All Fields] OR "cannulations"[All Fields]) AND ("bone screws"[MeSH Terms] OR "bone screws"[All Fields] OR "screw"[All Fields] OR "screwed"[All Fields] OR "screwing"[All Fields] OR "screws"[All Fields]))	2367
#3	("femoral neck fractures"[MeSH Terms] OR "femoral neck fractures"[All Fields] OR "femoral neck fracture"[All Fields] OR "FNFs"[All Fields])	11321
#4	#1 AND #2 AND #3	83

Table S2. The search strategy and results of Embase

Search	Query	Items found
#1	(fns OR (('femoral neck'/exp OR 'femoral neck') AND system))	6051
#2	cannulated AND (screws OR 'screw'/exp OR screw)	2736
#3	('femoral neck fracture'/exp OR 'femoral neck fracture' OR 'femoral neck fractures'/exp OR 'femoral neck fractures' OR fnfs)	10221
#4	#1 AND #2 AND #3	110

Table S3. The search strategy and results of the cochrane library

Search	Query	Items found
#1	MeSH descriptor: [Femur Neck] explode all trees	478
#2	("femur neck" OR "femoral neck"):ti,ab,kw (Word variations have been searched)	4028
#3	#1 OR #2	4028
#4	(system OR systems):ti,ab,kw (Word variations have been searched)	228781
#5	#3 AND #4	383
#6	(FNS):ti,ab,kw (Word variations have been searched)	74
#7	#5 OR #6	454
#8	(cannulate OR cannulated OR cannulating OR cannulator OR cannulators OR cannulisation OR cannulization OR cannulized OR catheterization OR cannulation OR cannulations):ti,ab,kw (Word variations have been searched)	13531
#9	MeSH descriptor: [Bone Screws] explode all trees	851
#10	(screw OR screwed OR screwing OR screws):ti,ab,kw (Word variations have been searched)	3918
#11	#9 OR #10	3918
#12	#8 AND #11	166
#13	MeSH descriptor: [Femoral Neck Fractures] explode all trees	458
#14	("femoral neck fractures" OR "femoral neck fracture" OR "FNFs"):ti,ab,kw (Word variations have been searched)	1107
#15	#13 OR #14	1107
#16	#7 AND #12 AND #15	13

Table S4. The search strategy and results of Web of Science

Search	Query	Items found
#1	("FNS" OR (("femur neck" OR "femoral neck") AND ("system" OR "systems"))) (All Fields)	4981
#2	(("cannulate" OR "cannulated" OR "cannulating" OR "cannulator" OR "cannulators" OR "cannulisation" OR "cannulization" OR "cannulized" OR "catheterization" OR "cannulation" OR "cannulations") AND ("bone screws" OR "screw" OR "screwed" OR "screwing" OR "screws")) (All Fields)	1776
#3	"femoral neck fractures" OR "femoral neck fracture" OR "FNFs" (All Fields)	4876
#4	#1 AND #2 AND #3	75