META-ANALYSIS

Femoral neck system versus dynamic hip screw for fixation of femoral neck fracture in the adult: a meta-analysis

Qi Long Jiang[1], Yong Cao[2], Xinwen Bai[3], Yu Deng[4], Yan Li[5]

Abstract

Objective: To determine the efficacy of femoral neck system compared to dynamic hip screws in treating femoral neck fractures.

Method: The systematic review was conducted from January to March 2023, and comprised literature search on PubMed, Embase, Scopus, Ovid, Cochrane Central Register of Controlled Trials, China National Knowledge Infrastructure and Wanfang databases for relevant studies published up to March 1, 2023. Study data as well as demographic and outcome parameters related to the patients were extracted, and the methodological index for non-randomised studies was used to assess the risk of bias. Review Manager software was used to conduct meta-analysis.

Results: Of the 567 studies initially found, 6(1%) were included, with the publication date ranging from August 2021 to February 2023. There were 5(83.3%) studies published in English and 1(16.7%) in Chinese. Of the 577 patients with femoral neck fractures, 287(49.7%) were treated with femoral neck system and 290(50.3%) with dynamic hip screws. Significant differences were shown between the two groups regarding operation duration, blood loss, internal fixation failure rate and Harris hip score ($p=<0.05$). There was no significant differences between the groups regarding time from injury to surgery, hospitalisation, complication rate and femoral neck shortening rate ($p>0.05$).

Conclusion: The novel femoral neck system could optimise surgical procedures, with shorter operation times and lesser blood loss. The femoral neck system and dynamic hip screws were comparable in terms of complication rates and postoperative hip function.

Key Words: Femoral neck fractures, Internal fixators, Meta-analysis.

(JPMA 74: 335; 2024) **DOI: https://doi.org/10.47391/JPMA.9556**

Introduction

Femoral neck fractures (FNFs) have been ranked globally among the top 10 causes of disability, and are projected to account for 21 million cases in the next 40 years.[1] Proper surgical intervention has been proven to be the optimal treatment strategy. The elderly population aged >65 years, sustaining displaced fracture patterns (Garden type¨ ,¨),[2] may benefit more from total hip arthroplasty or hemiarthroplasty.[3] Apart from the aforementioned exceptions, anatomical reduction with internal fixation is deemed to be the mainstay of treatment option. Conventional internal fixation devices mainly include cannulated cancellous screws (CCSs) and dynamic hip screws (DHSs).[4] CCSs are widely used to treat non-displaced FNFs due to the advantage of minimal invasion, less blood loss, and low cost. However, for patients with unstable or osteoporotic FNFs, high incidences of implant failure have been frequently reported. DHS could provide superior performance of stability, with greater trauma in operative procedures. The impeccable implant option seemed to be unattainable.[4] In 2018, a novel femoral neck system (FNS) was devised to treat FNFs in adult patients. This new implant purportedly combines the advantages of CCS and DHS, indicating exceptional biomechanical stability and minimal invasion.[5] With its application in recent years, adequate number of studies and reviews comparing FNS with CCS have been published,[6] while there are only a few studies assessing the clinical efficacy of FNS versus DHS.[7-12] No relevant systematic review could be retrieved from mainstream databases. As such, the current systematic review was planned to fill the gap through meta-analysis to clarify the clinical performance of FNS compared to DHS in adult FNF patients.

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Submission complete: 17-04-2023 **Review began**: 04-06-2023

Acceptance: 08-11-2023 **Review end:** 04-10-2023

Materials and Methods

This systematic review and meta-analysis was conducted from January to March 2023 Using the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines.[13]

PubMed, Embase, Scopus, Ovid, Cochrane Central

Register of Controlled Trials, China National Knowledge Infrastructure and Wanfang electronic databases were searched from their respective date of inception up to March 1, 2023. Search terms and Boolean Operators included femoral neck fractures OR femoral neck fracture (TIAB) OR femur neck fractures (TIAB) OR femur neck fracture (TIAB) OR neck of femur fracture (TIAB) AND femoral neck system (TIAB) OR femoral neck fixation system (TIAB) OR FNS (TIAB). No language restrictions were applied during the search. The article screening was independently carried out by two surgeons. The consensus on selection was reached by discussion with a third researcher. Additional reference screening of the included studies was performed for relevant eligible articles.

Those included were studies comparing FNS and DHS in adult FNF patients regardless of fracture classification, stability, energy-related mechanism and degree of osteoporosis. Outcome parameters were not restricted either. After title and abstract screening, biomechanical, cadaveric and laboratory studies were excluded.

Data was extracted from the included studies using predesigned proforma by two independent surgeons. Extracted data included authors, publication year, country, study design, implant type, number of cases, mean age, gender distribution, Garden and Pauwels classification distribution,[2, 14] and outcome parameters like time to surgery, operation time, blood loss, hospitalisation time, complication rate, femoral neck shortening, implant failure rate and Harris hip score (HHS).[15]

The Methodological index for non-randomised studies (MINORS) was used to assess the risk of bias in the included studies. The assessment of items comprised a clearly stated aim, the inclusion of consecutive patients, prospective collection of data, endpoints appropriate to the aim of the study, unbiased assessment of the study endpoints, follow-up period appropriate to the aim of the study, loss to follow-up <5%, prospective calculation of the study size, an adequate control group, contemporary groups, baseline equivalence of groups, and adequate statistical analysis.Meta-analysis was done using Review Manager software 5.4.1 (Nordic Cochrane Centre, Cochrane Collaboration, Denmark). Only outcome parameters reported in 3 or more studies were used for meta-analysis. For continuous variables, either mean difference (MD) or standardised mean difference (SMD) was calculated, while odds ratio (OR) was utilised for dichotomous variables. All estimates were presented with 95% confidence interval (CI). The random-effects model was used for all outcome parameters due to clinical heterogeneity. Forest plots were generated to provide a visual view of analysed outcomes. P<0.05 was considered statistically significant.

Results

Of the 567 studies initially found, 6(1%) were included

Table-1: Characteristics of the studies analysed.

	Author	year	Country	Study design	Group	No. Of patients	Mean age(years)	Gender (Male / Female)	Garden (I/II/III/IV)	Pauwels (I/II/III)	Follow-up (months)	Outcomes
1	Ge et al.[7]	2023	China	Retrospective	FNSDHS	43 52	50.4 ± 7.4 48.2 ± 8.0	60 / 13 37 / 15	5 / 26 / 12 / - 7 / 29 / 16 / -	5 / 10 / 28 8 / 14 / 30	25.8 ± 4.2 24.3 ± 3.1	a, b, c, f, g, h, i, j, k
2	Hong et al.[11]	2023	China	Prospective	FNSDHS	50 43	54.63 ± 9.87 55.43 ±10.27	32 / 18 28 / 15	- / 17 / 25 / 8 - / 15 / 22 / 6	NA	Mean 6 months	b, c, d, g, k, l, m, n, o
3	Niemann et al.[8]	2022	Germany	Retrospective	FNSDHS	12 19	66.5 ± 10.98 60.47 ± 17	6 / 6 9 / 10	1 / 8 / 2 / 1 2 / 9 / 4 / 4	1 / 7 / 4 1 / 10 / 8	NA	a, b, e, p, q, r
4	Schuetze et al.[9]	2022	Germany	Retrospective	FNSDHS	113 108	70.6 ± 14.9 68.5 ± 15.1	54 / 59 55 / 53	16 / 56 / 30 /11 22 / 49 / 29 / 8	5 / 68 / 40 11 / 58 / 39	Mean 13 months	a, b, f, h, p, s, t
5	Vazquez et al.[10]	2021	Switzerland	Retrospective	FNSDHS	15 16	86.1 ± 4.6 83.4 ± 7.3	2 / 13 6 / 10	NA	NA	NA	a, b, f, r, u, v, w
6	Xu et al.[12]	2022	China	Retrospective	FNSDHS	54 52	60.7 ± 15.2 63.1 ± 13.2	18 / 36 14 / 38	II 35 / III-IV 16 -II 43 / III-IV 9	14 / 24 / 16 17 / 25 / 10	12 ± 1.5 14.5 ± 0.94	a, b, c, d, e, f, g, h, i, j

FNS: Femoral neck system. DHS: Dynamic hip screw, NA: Not available, a: Days of hospitalisation, b: Operation time, c: Blood loss, d: Intraoperative fluoroscopy time, e: Weight-bearing time, f: Length of femoral neck shortening, g: Harris hip score, h: Internal fixation failure, i: Bone nonunion, j: Avascular necrosis of the femoral head, k: Incision length, l: Fracture reduction quality, m: Fracture healing time, n: Reoperation, o: Visual analogue scale, p: Time to surgery, q: Postoperative Pauwels angle, r: Discharge status, s: Implant related infection, t: Tip apex, u: Readmissions, v: Blood transfusion, w: Death.

(Figure 1),[7-12] with the publication date ranging from August 2021 to February 2023. There were 5(83.3%) studies published in English and 1(16.7%) in Chinese. Of the 577 FNF patients, 287(49.7%) were treated with FNS and 290(50.3%) with DHS. No significant differences regarding age, gender, injury type and fracture pattern were found among the studies analysed (Table 1). The studies had a MINORS score ranging 18-21 points (Table 2).

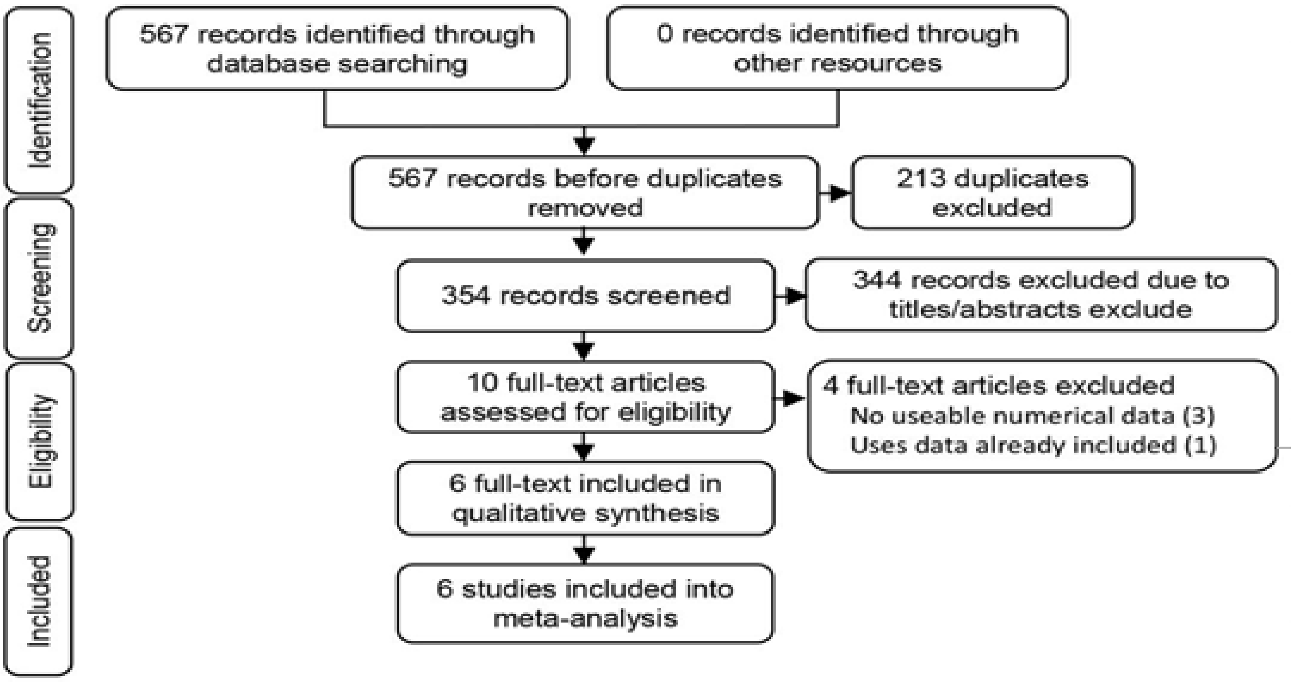

Figure-1: Study flow-chart.

Table-2: Risk of bias assessment using methodological index for non-randomised studies (MINORS).

No.	Author of study	A	B	C	D	E	F	G	H	I	J	K	L	Total Score
1	Ge et al.[7]	2	1	2	2	2	2	2	0	2	2	2	2	21
2	Hong et al.[11]	2	1	2	2	2	1	2	1	2	2	2	2	21
3	Niemann et al.8	2	2	2	1	2	0	2	0	2	2	2	2	19
4	Schuetze et al.9	2	1	2	2	2	2	2	0	2	2	2	2	21
5	Vazquez et al.10	2	1	2	1	2	0	2	0	2	2	2	2	18
6	Xu et al.12	2	1	2	2	2	2	2	0	2	1	2	2	20

A: A clearly stated aim. B: Inclusion of consecutive patients, C: Prospective collection of data, D: Endpoints appropriate to the aim of the study. E: Unbiased assessment of the study endpoints. F: Follow-up period appropriate to the aim of the study. G: Loss to follow-up <5%, H, Prospective calculation of the study size, I: An adequate control group, J: Contemporary groups, K: Baseline equivalence of groups, L: Adequate statistical analysis.

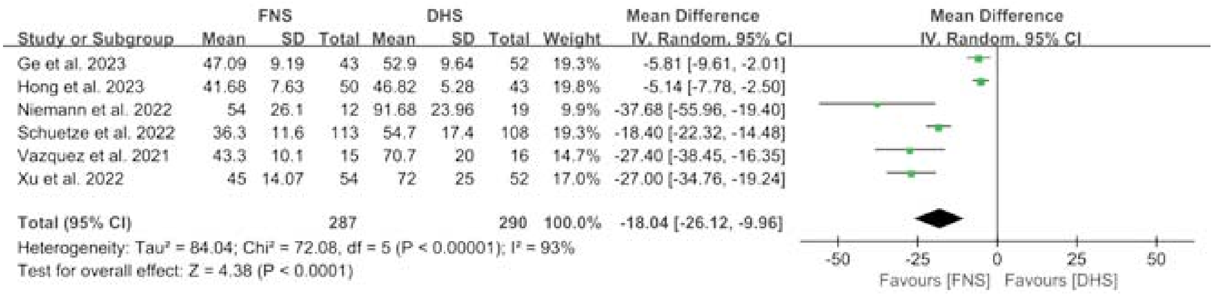

Figure-2: Operation duration (min),

FNS: Femoral neck system. DHS: Dynamic hip screw, SD: Standard deviation, CI: Confidence interval.

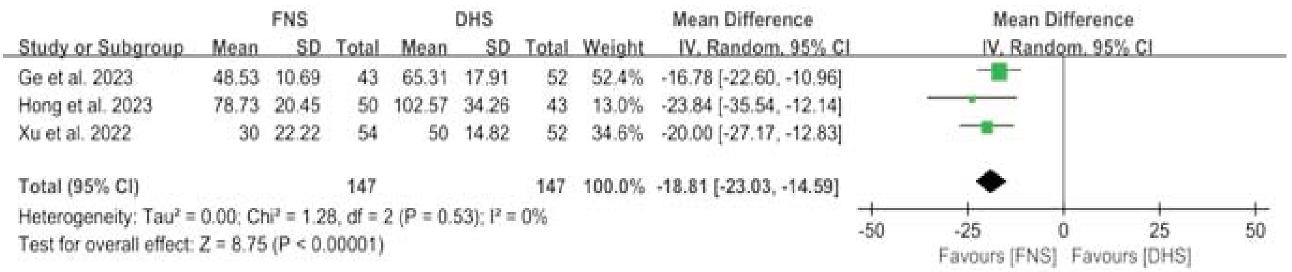

Figure-3: Blood loss (ml).
FNS: Femoral neck system. DHS: Dynamic hip screw, SD: Standard deviation, CI: Confidence interval.

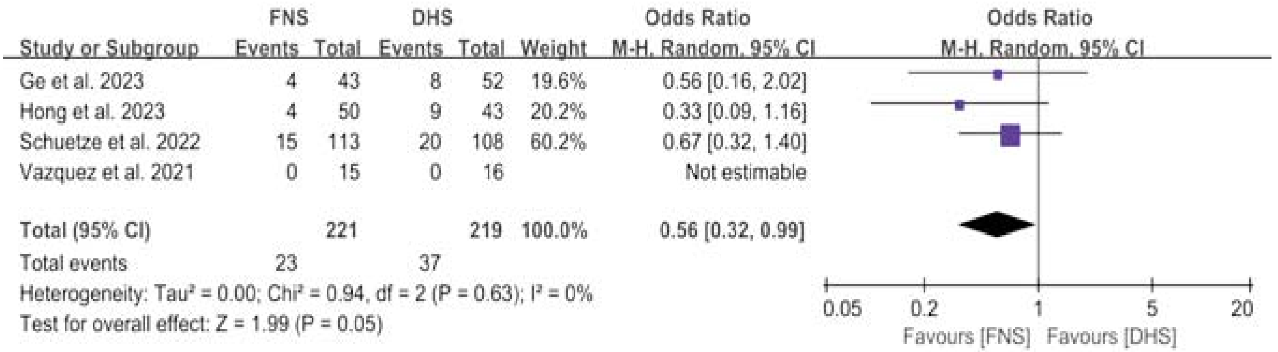

Figure-4: Complication rate.
FNS: Femoral neck system. DHS: Dynamic hip screw, CI: Confidence interval.

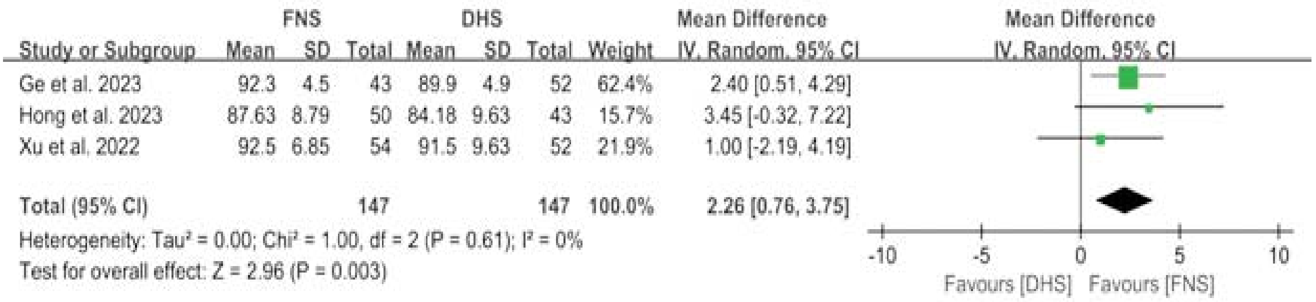

Figure-5: Harris hip scores.
FNS: Femoral neck system. DHS: Dynamic hip screw, SD: Standard deviation, CI: Confidence interval.

There were 3(50%) studies reporting data on time from injury to surgery,[8,9,12] and there was no significant difference in this regard (MD: -1.34 hours, 95% CI: -5.81, 3.14, p=0.56).

Operation time was reported in all 6(100%) studies,[7-12] with the FNS group showing significantly shorter operation time (MD -18.04 minutes, 95% CI: -26.12, -9.96, p<0.0001). A high level of heterogeneity was observed (p<0.0001, I2: 93%) (Figure 2).

There were 3(50%) studies that reported blood loss.[7, 11, 12] The FNS group had significantly lesser blood loss than the DHS group (MD: -18.81ml, 95% CI: -23.03, -14.59, p<0.0001). The heterogeneity level was low (p=0.53, I2: 0%) (Figure 3).

There were 5(83.3%) studies reporting hospitalisation duration in the 2 groups.[7-10, 12] There was no significant difference between FNS and DHS groups (MD: -1.03 days, 95% CI: -2.29, 0.23, p=0.11). A high level of heterogeneity was observed (p=0.0001, I2: 83%).

Overall surgical complications involving implant failure, haematoma, implant-related infection, femoral neck shortening, femoral head necrosis and nonunion identified within 6-30 months of follow-up, were reported by 3(50%) studies.[7, 9, 11] The complication rate in the FNS group was slightly lower compared to the DHS group (OR: 0.56, 95% CI: 0.32, 0.99, p=0.05), with a low level of heterogeneity (p=0.63, I2: 0%) (Figure 4).

The absolute value of femoral neck shortening was reported by 4(66.7%) studies,[7,9,10,12] with no significant difference between FNS and DHS groups (MD: -0.04mm, 95% CI: -1.07, 0.99, p=0.94). Of these 4(66.7%) studies, 3(75%) reported the rate of femoral neck shortening >5mm,[7,9,12] and pooled data showed no significant difference between the groups (OR 0.92, 95% CI: 0.59, 1.42, p=0.70). There was Inconsistent heterogeneity of the two estimate methods was found (I2; 68% and I2: 0% respectively).

The rate of internal fixation failure was reported by 3(50%) studies.[9,11,12] Internal fixation failure was defined as internal fixation screw breakage, implant cut-out, and fracture nonunion. No significant difference was demonstrated in pooled data (OR: 0.56, 95% CI: 0.32, 0.99, p=0.05), with a low level of heterogeneity (p=0.45, I2: 0%).

Of the total, 3(50%) studies reported postoperative hip function using the HHS at the final follow-up.[7,11,12] Pooled analysis showed that the FNS group had significantly higher scores compared to the DHS group (MD 2.26, 95% CI: 0.76, 3.75, p=0.003), with a low level of heterogeneity (p= 0.61, I2: 0%) (Figure 5).

Discussion

FNS consists of three parts: the plate and locking screw, the screw bolt, and the anti-rotation screw. This fixed-angle system can provide compression quality, angular stability with a neck-shaft angle (130 degrees), and rotational stability.[5] The plate and screws can be placed by taking a minimally invasive approach. The fixation strength, compression quality and angular stability combining the advantages of CCS with DHS had been corroborated by several finite element analyses. Samuel et al. performed a study comprising 105 patients who received FNS for FNFs. One-year implant failure rate 13% and mortality rate 21% were reported.[16] Amit et al. retrospectively analysed a multi-centre study cohort of 102 FNF patients managed with FNS, and demonstrated that the FNS group had significantly lower complication rates compared to CCS and DHS fixation groups.[17]

In the present review, inter-operation parameters, including operation duration and blood loss, indicated that the FNS group had statistical superiority over the DHS group, given that this new-type device was utilised with much less experience. Actually, slightly reduced blood loss in the FNS group would be less likely to bring out clinical significance, but significantly lesser operation time may be associated with lesser anaesthesia duration, reduced fluoroscopy exposure, and decreased infection rate, which had been corroborated by limited data in the studies analysed.[7-12] The optimised surgical procedure may be in correlation with less adjustment of device insertion. Additionally, Ge et al. reported that surgical incision length in the FNS group (4.04±0.43mm) was much shorter than in the DHS group. Peri-operation outcomes involving time to surgery, hospitalisation duration, and American Society of Anaesthesiologists scores (ASA) showed no significant difference between the groups.[7] In terms of simplification of surgical procedures, FNS demonstrated significant superiority over DHS.[7, 11, 12]

In contrast, overall complication rates between FNS (23/221, 10.4%) and DHS (37/219, 16.9%) showed no significant difference in 4 studies,[7, 9-11] comparable to previous reviews (20/215, 9.3%). Both FNS and DHS showed lower complication rates compared to the CCS group (74/260, 28.5%).[18] Complications following treatment of FNFs include femoral neck shortening, femoral head avascular necrosis, bone nonunion, varus deformity, implant failure, implant-related infection, and reoperation. Theoretically, FNS and DHS share similarities in the characteristics of angular stability, rotational stability and dynamisation, which had been proven by several biomechanical studies and finite element analyses.[19,20] In the present meta-analysis, the clinical performance of FNS and DHS seemed to support the finding. Femoral neck shortening has been deemed to be the most common complication postoperatively and correlates significantly with hip functional outcomes. This is due to the absorption in fracture ends and limited dynamisation from the implant. In the studies anlysed, the difference in both the shortening value and shortening rate (>5mm) indicated no statistical significance, which favoured the CCS. Moreover, pooled implant failure rates were comparable in the FNS group (18/ 217, 8.3%) and the DHS group (16/203, 7.9%) in 3 studies.[9,11,12] Cut-out at the blade side constituted the majority of failure cases. The 1-hole plate represented a higher risk of implant failure compared to the 2-hole plate.[9] Between age subgroups (older or younger than 60 years of age), no significant differences were found in implant failure rate.[12]

In terms of postoperative hip function, HHS was used to assess at the last follow-up (range 6-30 months), with substantial clinical heterogeneity. The FNS group showed higher scores than the DHS group, but the relevant heterogeneity and precision should be taken into account to make a conclusive statement.

The current review has certain limitations. First, the small sample size and patchy follow-up time may reduce the strength of the study. This is mainly due to the short duration of the clinical application of FNS. Second, the studies analysed were mainly retrospective research with inherent selection bias. Finally, the current systematic review was not prospectively registered with the Prospective Register of Systematic Reviews (PROSPERO) or any other international database. This may affect negatively the standardisation of the study.

More high-quality randomised controlled trials (RCTs) are required to establish a greater degree of accuracy on the matter.

Conclusion

The novel FNS could optimise surgical procedures, with shorter operation times and lesser blood loss. The FNS and DHS were comparable in terms of complication rates and postoperative hip function.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

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Author's Contributions
QJ, JL, YL: Interpretation of data and draft of the manuscript.
JL, BY, MY: Literature search.
XB, YD, HH: Data extraction and analysis.
QJ, YL, YC: Contributed equally to the study conception and design and should be regarded as the co-first authors.
All authors commented on the final manuscript, final approval and agreed to be accountable for all aspects if the work.