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ORIGINAL ARTICLE

Comparison of complications between total hip arthroplasty following failed internal fixation and primary total hip arthroplasty for femoral neck fractures: A meta-analysis

Haotian Yin,[1*] Yixiang Zhang,[1,2*] Wenbo Hou,[1] Lei Wang, MD[1] Xin Fu, MD[1] Jun Liu, MD[1]

[1]Department of Joints, Tianjin Hospital of Tianjin University (Tianjin Hospital), Tianjin, China
[2]Clinical College of Orthopedics, Tianjin Medical University, Tianjin, China

ABSTRACT

Objectives: In this meta-analysis, we discuss the complication rates of conversion to total hip arthroplasty (cTHA) following failed internal fixation (IF) of femoral neck fractures (FNFs) versus primary total hip arthroplasty (pTHA).

Materials and methods: The Cochrane Library, Web of Science, PubMed, Embase, and Science Direct databases were searched for eligible publications published prior to December 2024. The search terms included "femoral neck fracture", "internal fixation failure", and "total hip arthroplasty". The mean difference (MD) and risk difference (RD) were used as combined variables, and 95% confidence intervals (CIs) were chosen.

Results: Six non-randomized-controlled clinical trials comprising 1,301 patients were included in this meta-analysis. The pooled data revealed statistically significant differences in postoperative deep infection rates (RD=0.04; 95% CI: 0.01-0.08; p=0.009), periprosthetic fractures (RD=0.03; 95% CI: 0.00-0.05; p=0.03), and reoperation rates (RD=0.07; 95% CI: 0.03-0.11; p=0.0002) between the cTHA and pTHA groups. However, no significant differences were observed in the incidence of postoperative dislocations (RD=0.05; 95% CI: –0.03-0.13; p=0.19), deep vein thrombosis (RD= –0.01; 95% CI: –0.04-0.03; p=0.77), superficial infections (RD=0.02; 95% CI: –0.02-0.06; p=0.37), or revision surgeries (RD=0.02; 95% CI: –0.01-0.05; p=0.13).

Conclusion: Compared to pTHA, cTHA following failed IF of FNFs was associated with higher deep infection, periprosthetic fractures, and reoperation rates.

Keywords: Femoral neck fracture, internal fixation failure, meta-analysis, total hip arthroplasty.

Femoral neck fractures (FNFs) affect approximately 1.3 to 2.2 million individuals every year worldwide, with the potential to increase mortality, adverse events, and serious socioeconomic burdens, and their incidence rate is projected to exceed 6 million individuals per year by 2050.[1,2] Internal fixation (IF) and total hip arthroplasty (THA) are the preferred treatments for FNFs, with physicians often preferring IF for the majority of young and active FNFs, and IF is more acceptable to patients as a hip-sparing treatment.[3] However, in elderly patients, owing to the poor blood supply to the proximal end of the fracture after FNF, IF treatment may be ineffective in these patients due to ischemic necrosis of the femoral head, infection at the surgical site, or worsening of symptoms.[4,5] Kalsbeek et al.[6] reported that, in their meta-analysis, age and inadequate fracture reduction were identified as significant risk factors for IF treatment failure. However, despite achieving adequate reduction (or perfect reduction) in displaced FNF there remains a 27% incidence

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Correspondence: Jun Liu, MD. Department of Joints, Tianjin Hospital of Tianjin University (Tianjin Hospital), 300211 Tianjin, China.

E-mail: liujun1968tju@163.com

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* *These authors contributed equally to this work.*

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of femoral head necrosis following IF, along with a 9.8% rate of fracture non-union. Additionally, approximately one-third of patients who undergo IF ultimately require conversion to THA (cTHA).[7]

Salvage THA for FNF with failed IF is more complex, has more postoperative complications, and is more technically challenging than primary THA (pTHA) for other indications, such as primary osteoarthritis or femoral head necrosis.[8] However, it remains controversial whether cTHA is as safe and effective as pTHA and whether it increases complications. Mahmoud et al.[9] conducted a meta-analysis which compared the clinical outcomes of salvage THA following failed IF with those of pTHA. However, significant heterogeneity in the patient selection criteria somewhat undermines the rigor of the conclusions. In the light of new studies published in recent years,[10,11] a new meta-analysis is warranted to incorporate additional data, thereby enabling a more comprehensive and precise assessment of the differences in postoperative complications between cTHA and pTHA.

In the present study, we aimed to provide a reference for the treatment of elderly patients with FNFs by comparatively analyzing complications between cTHA after failed IF and pTHA.

MATERIALS AND METHODS

Search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines served as the basis for this meta-analysis. The search terms "femoral neck fracture", "internal fixation failure", and "total hip arthroplasty" were used; the Cochrane Library, PubMed, ScienceDirect, Web of Science, and Embase databases were searched, with these terms being limited to the title or abstract; and the publication date or study type was not limited, with the search ending in December 2024. Duplicates were first deleted and, then, titles and abstracts were checked individually to exclude irrelevant studies. For initially identified studies and relevant systematic reviews, the full text was accessed and browsed for final inclusion of eligible studies. References of the articles which were identified were also examined for potential related issues. Ethical approval was not required for this meta-analysis, as it utilized data exclusively from previously published sources. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Inclusion criteria

In this meta-analysis, the Study Population, Intervention, Comparator, Outcomes, and Study (PICOS) design was used to determine inclusion criteria. Studies were selected and subjected to quality assessment and data extraction on the basis of the following inclusion criteria: *(i)* patients who underwent THA; *(ii)* the research was divided into two groups, namely the cTHA group and the pTHA group; and *(iii)* indicators of observation: dislocations, superficial infections, deep infections, deep vein thrombosis (DVT), periprosthetic fracture, reoperation, revision, and other postoperative complications. The eligibility of the articles for inclusion was ascertained based on the opinions of two separate investigators. In case of disagreement, basic information about the literature was omitted, and the final decision was made by a third researcher.

Exclusion criteria

Studies were excluded for the following reasons: *(i)* duplication of published literature, reviews of nonprimary studies, case reports, conference reports, meta-analyses, and basic studies; *(ii)* interventions which did not meet the inclusion criteria; *(iii)* inaccurate, incomplete, and difficult extraction of primary data; and *(iv)* studies reporting irrelevant results.

Data extraction

Data were retrieved separately from the included publications by two investigators. The first author's name, year of publication, sample size, study type, and intervention were among the information and data retrieved. Dislocation, superficial infection, deep infection, DVT, periprosthetic fracture, reoperation, revision, and other postoperative problems were among the outcome indicators.

Quality assessment

All eligible studies underwent rigorous independent evaluation by two reviewers. The methodological quality of the included randomized-controlled trials (RCTs) was meticulously assessed in accordance with the guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions.[12] For non-RCTs, the Methodological Index for Non-Randomized Studies (MINORS) was utilized to evaluate their quality.[13]

Statistical analysis

Statistical analysis was performed using the RevMan version 5.4 software provided by the

Cochrane Collaboration. For continuous variables, mean differences (MDs) were expressed in the mean differences, and binary outcomes were expressed as risk differences (RDs), both of which were quantified using 95% confidence intervals (CIs). Heterogeneity was assessed by p-values and I^2 values. Using I^2 <50% and p>0.1, the heterogeneity of the combined statistical results between studies was considered low; therefore, a fixed-effects model was used for the combined analysis of the results. In contrast, there was considerable heterogeneity between the trials in which the random effects model was used for meta-analysis, and there was between-study heterogeneity.

RESULTS

Search results

A total of 1,167 potentially relevant research papers were identified, and no other studies were identified through other sources. A total of 210 duplicate studies were successfully identified and excluded using Endnote software. This was followed by a comprehensive review of titles and abstracts, which excluded 939 studies. Six papers were ultimately included after the full texts were read.[10,11,14-17] The study flowchart is shown in Figure 1.

Risk of bias assessment

For non-RCTs, scores ranged from 18 to 20 according to the MINORS criteria, reflecting the relative quality of the study design. The evaluation of the methodological quality of non-RCTs is presented in Table I.

Characteristics of the included studies

Table II displays the demographic features and additional information of the studies that were included.

Outcomes of the meta-analysis

Postoperative deep infections

Three studies[10,15,16] evaluated deep postoperative infections in patients, and there was no statistical heterogeneity among the studies (p=0.44, I^2=0%); therefore, fixed effects models were used for analysis. Pooling revealed that compared to cTHA, pTHA was associated with a lower risk of postoperative deep infection (RD=0.04; 95% CI: 0.01-0.08; p=0.009, Figure 2, Table III).

Postoperative DVT

Three studies[14-16] were included which assessed postoperative DVT, with no statistical heterogeneity among the studies (p=0.38, I^2=0%), and were

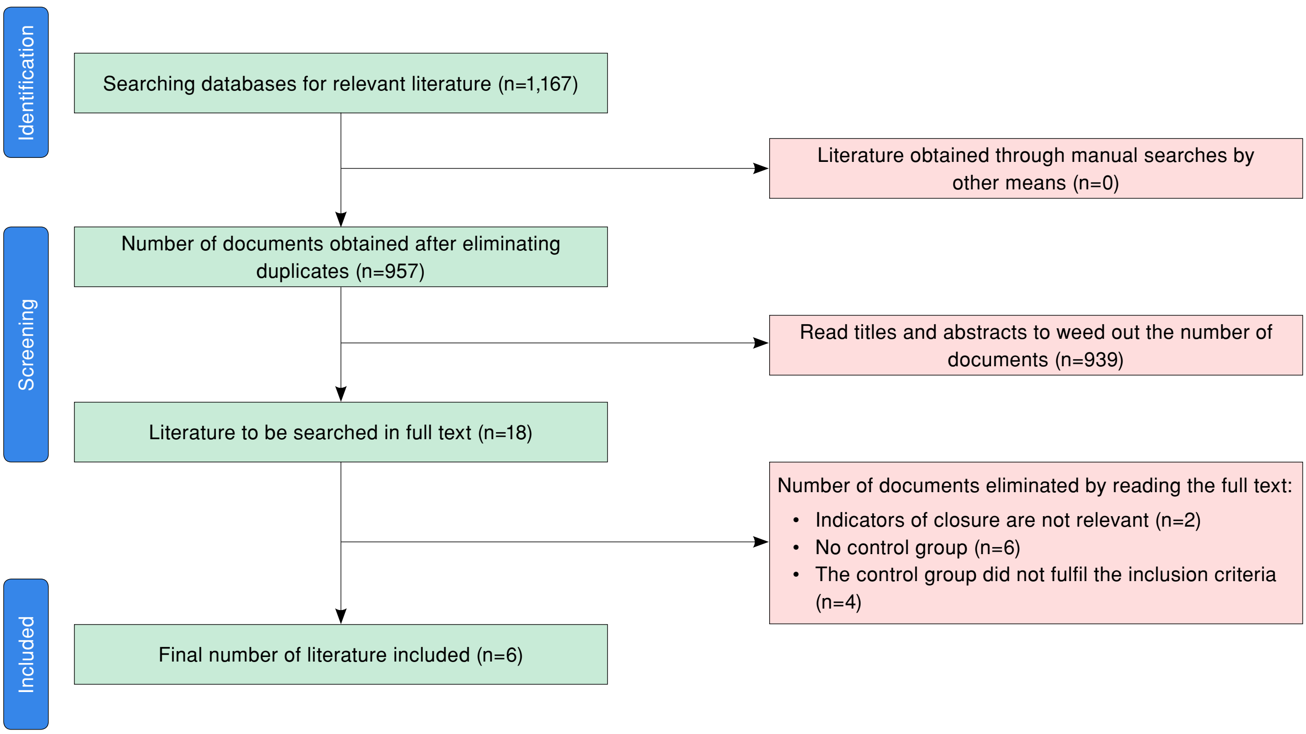

FIGURE 1. Study flowchart.

TABLE I
Quality assessment for non-randomized trials

Quality assessment for non-randomized trials	Blomfeldt et al.[14] 2006	Hung et al.[10] 2023	van Leent et al.[11] 2022	Mckinley and Robinson[15] 2002	Oztürkmen et al.[16] 2006	Winemaker et al.[17] 2006
A clearly stated aim	2	2	2	2	2	2
Inclusion of consecutive patients	2	2	2	2	2	2
Prospective data collection	0	0	0	0	0	0
Endpoints appropriate to the aim of the study	2	2	2	2	2	2
Unbiased assessment of the study endpoint	2	2	2	2	2	2
A follow-up period appropriate to the aims of study	2	2	2	2	2	2
Less than 5% loss to follow-up	1	1	1	1	2	0
Prospective calculation of the sample size	0	0	0	0	0	0
An adequate control group	2	1	2	2	2	2
Contemporary groups	2	2	2	2	2	2
Baseline equivalence of groups	2	2	2	2	2	2
Adequate statistical analyses	2	2	2	2	2	2
Total score	19	18	19	19	20	18

analyzed via a fixed-effects model. The pooled data revealed no significant difference in postoperative DVT between the two groups. (RD= –0.01; 95% CI: –0.04-0.03; p=0.77, Figure 3, Table III).

Postoperative dislocation

Postoperative dislocation data could be extracted from four studies,[10,11,15,16] with statistically significant heterogeneity between studies (p=0.003, I^2=79%), which were analyzed via a random effects model. The synthesis showed similar results in the pTHA and cTHA groups (RD=0.05; 95% CI: –0.03-0.13; p=0.19, Figure 4, Table III).

Postoperative periprosthetic fractures

Patients were included in five studies[11,15-17] with postoperative periprosthetic fracture indicators, with no statistical heterogeneity among the studies (p=0.36, I^2=8%), which were analyzed via a fixed-effects model. Pooled data showed that, compared to the cTHA group, patients in the pTHA group exhibited a lower risk of postoperative periprosthetic fractures (RD=0.03; 95% CI: 0.00-0.05; p=0.03, Figure 5, Table III).

Reoperation

Four studies[10,15-17] reported reoperation after THA, with no statistically significant heterogeneity among the studies (p=0.24, I^2=29%), and were analyzed via a fixed-effects model. The pooled finding was that patients with pTHA had a lower rate of postoperative reoperation than patients in the cTHA group did (RD=0.07; 95% CI: 0.03-0.11; p=0.0002, Figure 6, Table III).

Postoperative superficial infections

A total of 24 patients in the five studies[14,10,15-17] developed superficial infections, with statistically significant heterogeneity among the studies (p=0.06, I^2=56%), which were analyzed via a random-effects model. The aggregated findings indicated that the rate of postoperative superficial infections was comparable between the two groups (RD=0.02; 95% CI: –0.02-0.06; p=0.37, Figure 7, Table III).

Revision

Three studies[10,11,15] reported a total of 61 patients who underwent revision THA, with no statistical heterogeneity among the studies (p=0.32, I^2=11%), which was analyzed via a fixed effects model. The combined results revealed that both the pTHA and cTHA groups performed comparably in terms of the incidence of postoperative revision (RD=0.02; 95% CI: –0.01-0.05; p=0.13, Figure 8, Table III).

TABLE II
Characteristics of included studies

Study	Date	Design	Group	Cases	Age year (Mean±SD)	Female	Follow-up (year)
Blomfeldt et al.[14]	2006	RCS	cTHA	41	80±5.3	38	2.0
			pTHA	43	79±5.0	37	2.0
Hung et al.[10]	2023	RCS	cTHA	105	62.8±17.9	100	1.9±1.7
			pTHA	210	62.8±17.7	50	1.4±1.6
van Leent et al.[11]	2022	RCS	cTHA	284	66.5±8.2	184	5.0±3.5
			pTHA	264	64.0±9.5	176	5.0±3.5
Mckinley and Robinson[15]	2022	RCS	cTHA	107	73.0	82	6.5
			pTHA	107	72.0	82	7.0
Oztürkmen et al.[16]	2006	RCS	cTHA	34	68.0	26	3.18
			pTHA	34	67.5	26	3.1
Winemaker et al.[17]	2006	RCS	cTHA	36	71.0±12.5	25	1.0
			pTHA	36	NR	NR	1.0

RCS: Retrospective controlled study; cTHA: Conversion to total hip arthroplasty; pTHA: Primary total hip arthroplasty; NR: No report.

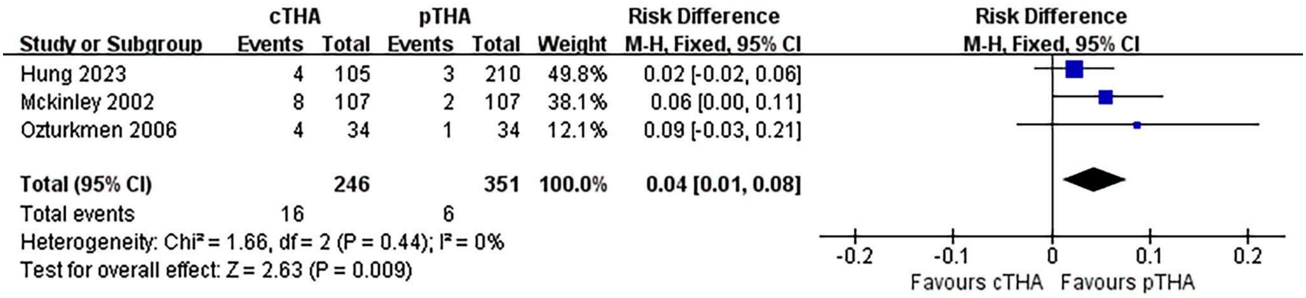

FIGURE 2. Postoperative deep infections (Forest plot).
cTHA: Conversion to total hip arthroplasty; pTHA: Primary total hip arthroplasty; CI: Confidence interval.

TABLE III
Meta-analysis results

Outcomes	Studies	Groups (cTHA/pTHA)	Effect estimate	Overall effect: 95% CI	Overall effect: *p*	Heterogeneity: I^2 (%)	Heterogeneity: *p*
Deep infections	3	246/351	0.04	0.01-0.08	0.009	0	0.44
Deep venous thrombosis	3	182/184	–0.01	–0.04-0.03	0.77	0	0.38
Dislocation	4	530/615	0.05	–0.03-0.13	0.19	79	0.003
Periprosthetic fractures	5	502/484	0.03	0.00-0.05	0.03	8	0.36
Reoperation	4	282/387	0.07	0.03-0.11	0.0002	29	0.24
Superficial infections	5	323/430	0.02	–0.02-0.06	0.37	56	0.06
Revision	3	496/581	0.02	–0.01-0.05	0.13	11	0.32

CI: Confidence interval; cTHA: Conversion to total hip arthroplasty; pTHA: Primary total hip arthroplasty.

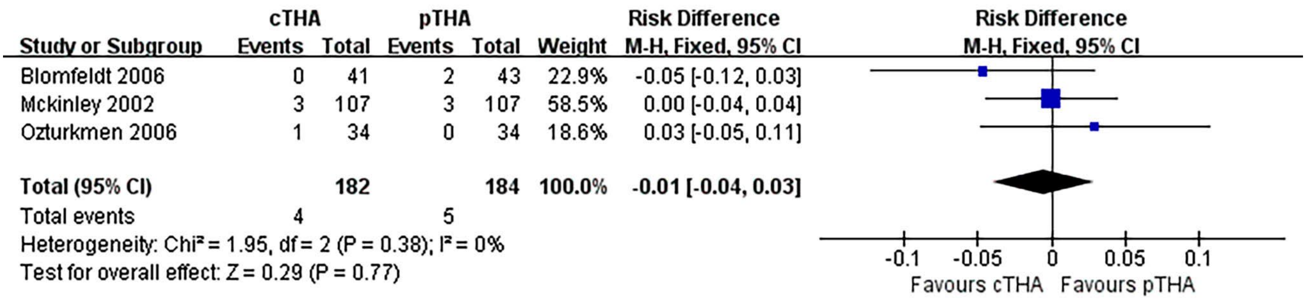

FIGURE 3. Postoperative DVT (Forest plot).
DVT: Deep vein thrombosis; cTHA: Conversion to total hip arthroplasty; pTHA: Primary total hip arthroplasty; CI: Confidence interval.

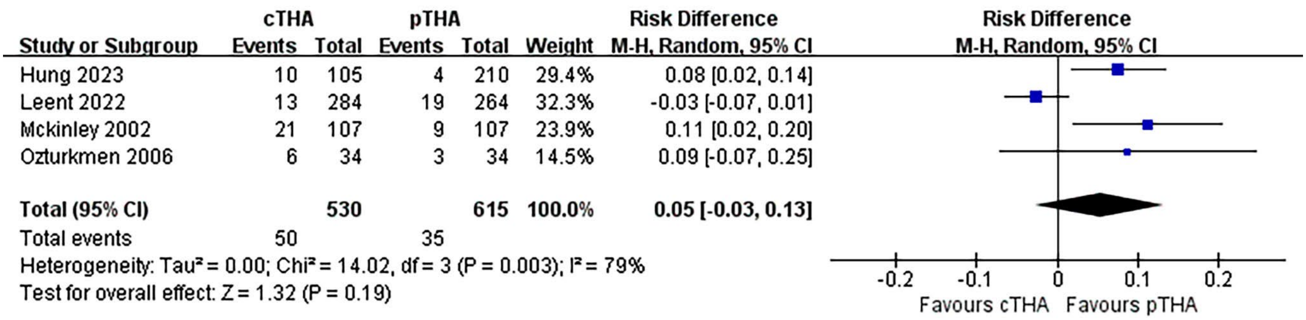

FIGURE 4. Postoperative dislocation (Forest plot).
cTHA: Conversion to total hip arthroplasty; pTHA: Primary total hip arthroplasty; CI: Confidence interval.

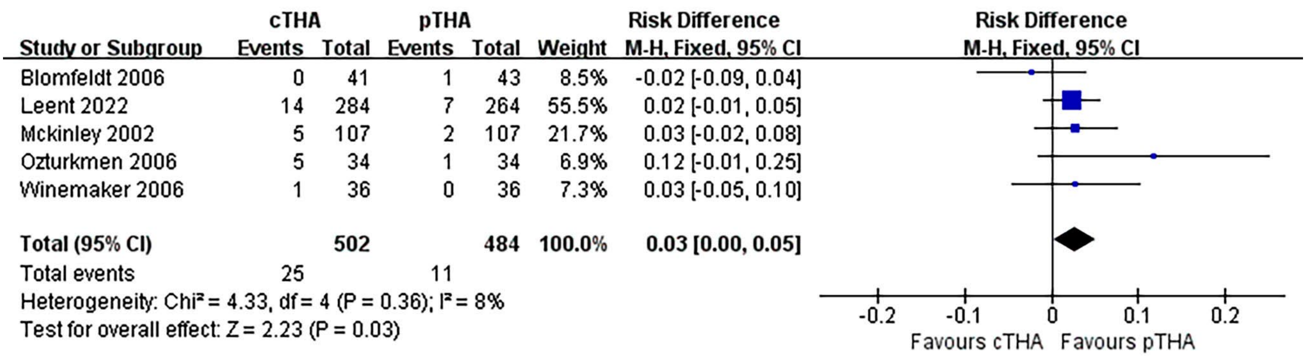

FIGURE 5. Postoperative periprosthetic fracture (Forest plot).
cTHA: Conversion to total hip arthroplasty; pTHA: Primary total hip arthroplasty; CI: Confidence interval.

DISCUSSION

Femoral neck fractures occur mostly in middle-aged and elderly individuals and are easily caused by falls, traffic accidents, and other types of physical trauma. Regardless of whether IF or THA is used, patient faces a high occurrence of postoperative complications and economic cost to the patient.[18,19] Patients with FNF failure often experience prolonged hip discomfort and a limited range of motion, which can lead to severe muscle atrophy and wasting osteoporosis prior to cTHA, factors that can increase the risk of postoperative complications after cTHA. In addition, the worsening of hip stiffness, osteoporosis, and synovitis make

Study or Subgroup	cTHA Events	cTHA Total	pTHA Events	pTHA Total	Weight	Risk Difference M-H, Fixed, 95% CI
Hung 2023	11	105	8	210	44.2%	0.07 [0.00, 0.13]
Mckinley 2002	8	107	2	107	33.8%	0.06 [0.00, 0.11]
Ozturkmen 2006	8	34	1	34	10.7%	0.21 [0.05, 0.36]
Winemaker 2006	2	36	1	36	11.4%	0.03 [-0.06, 0.12]
Total (95% CI)		**282**		**387**	**100.0%**	**0.07 [0.03, 0.11]**
Total events	29		12			

Heterogeneity: Chi² = 4.23, df = 3 (P = 0.24); I² = 29%
Test for overall effect: Z = 3.68 (P = 0.0002)

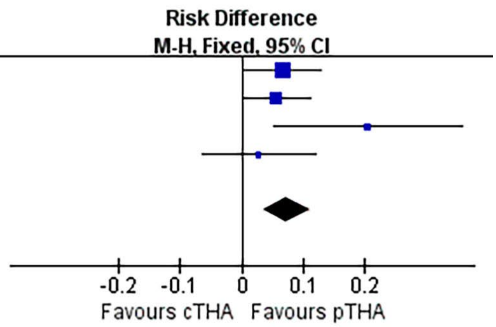

FIGURE 6. Reoperation (Forest plot).
cTHA: Conversion to total hip arthroplasty; pTHA: Primary total hip arthroplasty; CI: Confidence interval.

Study or Subgroup	cTHA Events	cTHA Total	pTHA Events	pTHA Total	Weight	Risk Difference M-H, Random, 95% CI
Blomfeldt 2006	0	41	2	43	17.6%	-0.05 [-0.12, 0.03]
Hung 2023	1	105	0	210	35.2%	0.01 [-0.01, 0.03]
Mckinley 2002	12	107	3	107	19.9%	0.08 [0.02, 0.15]
Ozturkmen 2006	3	34	2	34	9.2%	0.03 [-0.09, 0.15]
Winemaker 2006	1	36	0	36	18.2%	0.03 [-0.05, 0.10]
Total (95% CI)		**323**		**430**	**100.0%**	**0.02 [-0.02, 0.06]**
Total events	17		7			

Heterogeneity: Tau² = 0.00; Chi² = 9.00, df = 4 (P = 0.06); I² = 56%
Test for overall effect: Z = 0.90 (P = 0.37)

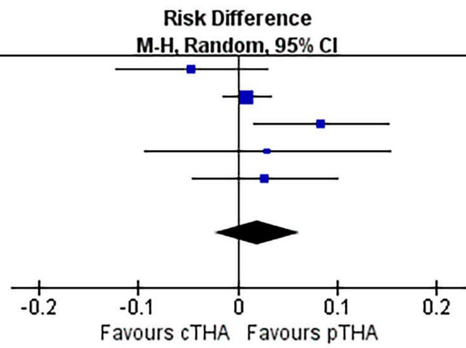

FIGURE 7. Postoperative superficial infections (Forest plot).
cTHA: Conversion to total hip arthroplasty; pTHA: Primary total hip arthroplasty; CI: Confidence interval.

Study or Subgroup	cTHA Events	cTHA Total	pTHA Events	pTHA Total	Weight	Risk Difference M-H, Fixed, 95% CI
Hung 2023	6	105	1	210	26.9%	0.05 [0.01, 0.10]
Leent 2022	22	284	19	264	52.6%	0.01 [-0.04, 0.05]
Mckinley 2002	8	107	5	107	20.6%	0.03 [-0.04, 0.09]
Total (95% CI)		**496**		**581**	**100.0%**	**0.02 [-0.01, 0.05]**
Total events	36		25			

Heterogeneity: Chi² = 2.26, df = 2 (P = 0.32); I² = 11%
Test for overall effect: Z = 1.52 (P = 0.13)

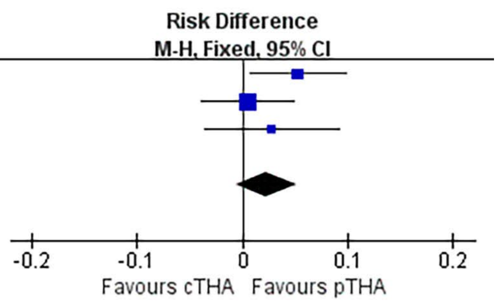

FIGURE 8. Revision (Forest plot).
cTHA: Conversion to total hip arthroplasty; pTHA: Primary total hip arthroplasty; CI: Confidence interval.

cTHA difficult to expose, prolong the duration of surgery, increase bleeding, and increase the risk of intraoperative fracture.[20]

This meta-analysis included six studies aimed at analyzing the incidence of postoperative complications after failed IF of FNFs by comparing cTHA with pTHA. The results revealed that patients in the pTHA group had a lower incidence of postoperative deep infections, periprosthetic fractures, and reoperations than did those in the cTHA group, but there were no significant differences between the two groups in terms of the incidence of postoperative dislocations, superficial infections, DVT, or revision.

Although superficial infections were not significantly different between the two groups, the rate of deep postoperative infections was higher in the cTHA group than in the pTHA group. Hung et al.[10] and Winemaker et al.[17] both reported that the surgical time for cTHA was significantly longer than that for pTHA, as the failed IF device must first be removed for cTHA and that patients in whom FNFs are fixed using screws are susceptible to difficulty in removal owing to the influence of the fracture healing sclerotic bands, as well as caudal osteophytes. The increased duration of surgical exposure may be a potential risk factor for deep infection. In addition, low-grade infections at the time of initial fixation may lead to delayed healing or bone non-union in patients. In particular, owing to inadequate examination of laboratory blood samples and joint fluid aspirates, these infections go undetected until the time of conversion to THA, which leads to a high rate of periprosthetic joint infections of up to 5.8% in the early postoperative period.[21] Therefore, while managing cases of failed IF of FNF, surgeons should be highly vigilant for the possibility of postoperative infection, including but not limited to monitoring C-reactive protein (CRP) levels to assess signs of infection and improve surgical success rates.[22]

In a previous meta-analysis by Mahmoud et al.,[9] the incidence of early postoperative dislocation and periprosthetic fracture was significantly greater in patients in the cTHA group than in those in the pTHA group. In contrast, although our study also found a higher risk of periprosthetic fractures in the cTHA group, no significant differences were observed between the two groups in terms of postoperative DVT or prosthetic dislocations. This may be due to the inclusion of patients who were successfully treated for FNFs with hemiarthroplasty and IF in the previous analysis, making the results inaccurate. Therefore, our analysis incorporated more recent studies and applied strict patient inclusion criteria. These improvements enabled a more precise quantification of the risk differences between cTHA and pTHA, offering more reliable evidence for clinical decision-making.

Infections, dislocations, periprosthetic fractures, and implant failures all contribute significantly to the increased rate of postoperative reoperation in patients.[23] Mahmoud et al.[9] indicated that complications such as deep infection, early prosthesis dislocation, and periprosthetic fracture can significantly increase the reoperation rate in the cTHA group. Our meta-analysis results, similarly, suggest that patients in the cTHA group have a higher rate of reoperation. It has been shown that, in cTHA patients after IF for FNF, a higher reoperation rate of approximately 18% has been reported, which is significantly higher than that in pTHA patients. Meanwhile, the most common cause of both reoperation and revision is dislocation of the prosthesis, as poorer bone quality in the cTHA leads to poorer osseointegration. Most dislocations occur within six months of salvage THA. Kwon et al.[24] reported in their study that, in THA performed via the posterior approach without soft tissue repair, the relative risk of dislocation is 8.21 times greater than that observed with soft tissue repair. Adequate soft tissue repair can significantly reduce the relative risk of dislocation. Therefore, we recommend intraoperative tightening of the soft tissue envelope, repair of the joint capsule, and reconstruction of the external rotators to reduce the risk of dislocation.[5,25]

Nonetheless, there are several limitations to this study. First, there were no RCTs in the included literature, and only six non-RCTs were included. Non-RCTs weakened the level of evidence in the meta-analysis. In addition, the age of the patients and the male-to-female ratio were not specified in some of the literature, and the duration of follow-up varied among the studies, which may have led to biased results.

In conclusion, compared to pTHA, cTHA after failed IF of FNFs is associated with higher rates of deep infection, periprosthetic fractures, and reoperation. Elderly patients can be treated with IF or THA in case of FNF; however, if IF fails, the risk of cTHA complications should be evaluated to achieve more satisfactory outcomes.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Contributed to conception and design of this study: H.T.Y., Y.X.Z., W.B.H., L.W., X.F., J.L.; Study selection and data extraction of the finally included studies were done independently assessed the methodological quality of each included study: by H.T.Y., Y.X.Z., W.B.H.; Contributed to preparation of the manuscript: H.T.Y., Y.X.Z., J.L. The final version of the article was approved by all the authors.

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