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Systematic Review

Conversion of a Failed Hip Hemiarthroplasty to Total Hip Arthroplasty: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: Hip hemiarthroplasty (HA) and total hip arthroplasty (THA) are common treatments for femoral neck fractures in elderly patients. Despite HA's advantages of shorter operative times, less blood loss, and lower initial costs compared to primary THA, it may lead to conversion THA (cTHA). Our objectives are to evaluate the impact of conversion from HA to THA on Harris hip scores (HHS), compare complication rates between cTHA, revision THA, and primary THA, and assess the rates and types of complications following cTHA.

Methods: A systematic review and meta-analysis were performed, evaluating studies published until 2023, with inclusion criteria entailing studies that explored outcomes and complications following cTHA of failed HA. Data extraction focused on variables such as postoperative HHS and complication rates, including periprosthetic joint infection, periprosthetic fracture, dislocation, stem loosening, acetabular loosening, and overall revision.

Results: This study included 28 retrospective studies (4699 hips), showing a mean increase in HHS by 39.1 points, indicating a significant improvement from preoperative levels. Complication rates were detailed, with a 6.4% rate of periprosthetic joint infection, 2.2% for periprosthetic fracture, 7.6% dislocation, 1.6% stem loosening, 1.9% acetabular loosening, and an overall re-revision rate of 8.7%.

Conclusions: Conversion from HA to THA generally results in improved functional outcomes, as evidenced by HHS improvements. Despite the positive impact on HHS, cTHAs are associated with notable risks of complications and the need for further revision surgeries.

Level of Evidence: IV.

Introduction

Hip fractures significantly impact the health-care system, with an estimated incidence of 340,000 per year in United States [1,2]. In 2010, it was estimated that the annual cost of managing hip fractures was between $17 and $20 billion [2,3]. Currently, the most common treatment for femoral neck fracture for elderly patients is hip hemiarthroplasty (HA) and total hip arthroplasty (THA) [4]. At 5 years, the revision rate, function, mortality, periprosthetic fracture (PPFX), and dislocation following HA and THA are likely similar [5]. HA has been shown to have shorter operative times, less blood loss, and lower initial costs than primary THA (pTHA) for proximal femur fractures [6-12].

Despite established efficacy, the deployment of HA is not without its limitations, notably an augmented risk of failure due to untreated acetabular cartilage wear, necessitating further interventions such as conversion THA (cTHA) [13,14]. Whereas several studies have explored the outcomes of converting failed HA to THA, a comprehensive meta-analysis showing the survival and outcomes of this surgery is absent in the existing literature [7-12,15-38]. This systematic literature review aims to collect data from the available research on HA to THA conversions. We propose to address the following questions:

1 Does conversion in failed cases cause improvement in Harris hip scores (HHS)? And how much?

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2 What are the complication rates of cTHA in their follow-up?
3 Does cTHA present higher complication rates than revision total hip arthroplasty (rTHA) and pTHA?

Material and methods

Study protocol

Our systematic review and meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. This review was registered in the PROSPERO prospective register of systematic reviews (CRD42022381376).

Search method

We systematically searched for studies reporting the revision and complications of HA to THA conversion in PubMed, EMBASE, and Cochrane (CENTRAL) from 1980 to January 2023. In summary, our search strategy was (hemiarthroplasty) AND ("total hip arthroplasty" OR "total hip replacement"). After the primary screening of the included studies, we conducted a forward and backward citation search using "Citation Chaser" [39]. We also performed a hand search of the keywords through gray literature in Google Scholar.

Study selection criteria

We identified eligible studies according to the population, intervention, control, outcomes, and study design to ensure the systematic search of available literature. We used the following inclusion criteria: (a) population: patients with failed HA; (b) intervention: cTHA; (c) control: we did not limit our search for the presence of a control group; (d) outcomes: changes in HHS, periprosthetic joint infection (PJI), PPFX, dislocation, revision due to stem loosening, revision due to acetabular loosening, overall revision; (e) study design: we expected papers to be case-series studies. However, we did not limit our search to any particular study design.

The exclusion criteria were as follows: studies involving animals and cell experiments; case reports, review articles, or conference abstracts; duplicate publications; mean follow-up of fewer than 2 years; non-English articles.

Identification of relevant studies

Our search, utilizing Citation Chaser, identified 879 potential studies. After the exclusion of duplicates and nonrelevant records, 28 studies, encompassing 4699 patients, were selected for systematic review and meta-analysis. A meticulous documentation of inclusion and exclusion processes is illustrated in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram (Fig. 1).

Data collection

Data extraction was systematically conducted by 2 independent reviewers (M.P. and M.L.), utilizing a standardized predesigned data collection form, targeting variables such as publication year, country, patient demographics, surgical details, clinical outcomes, and several other variables. In instances of disagreement, a third expert reviewer (S.M.J.M.) was consulted to confirm the final decision.

Quality assessment

The National Institute of Health quality assessment tool for case-series studies was used to evaluate and score the methodological quality of included studies.

Statistical analyses

Statistical analyses centered on our primary outcomes, namely the rates of PPFX, PJI, dislocation, stem loosening, acetabular loosening, and overall revision, were calculated per person and per person-year with 95% confidence intervals (95% CIs) when correlated with follow-up duration. Employing a random effects model,

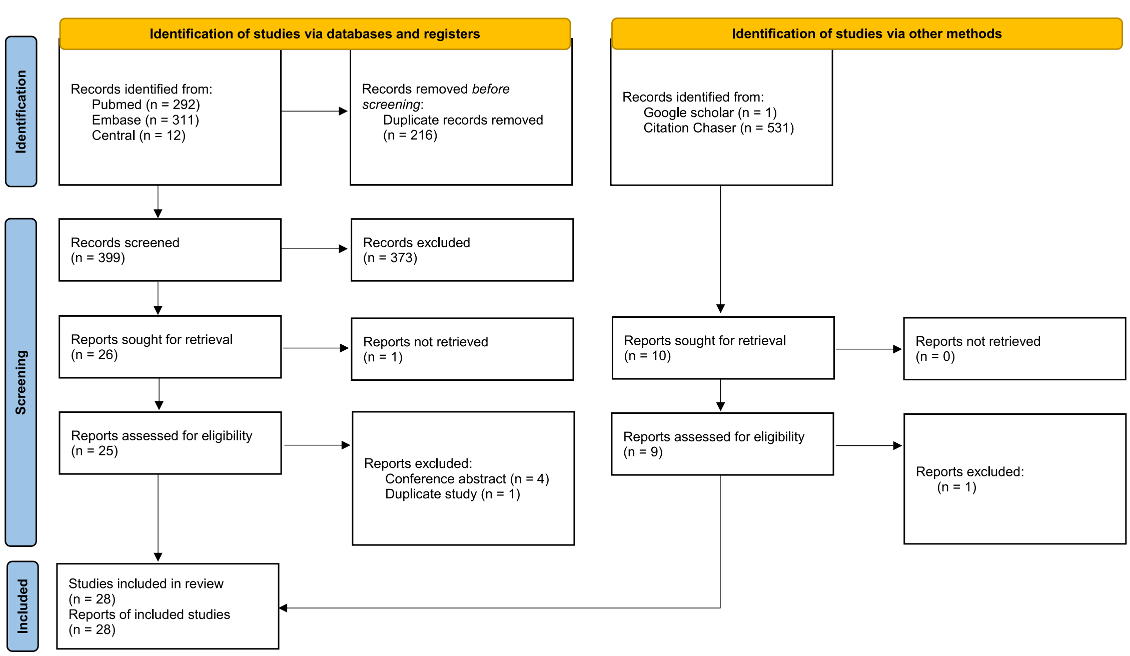


Figure 1. PRISMA flow diagram for study selection. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

outcome rates were pooled to mitigate the impact of between-study heterogeneity [40]. In cases of high heterogeneity, a sensitivity analysis is first performed to detect the outlier. If the heterogeneity remained high, in-depth meta-regression, utilizing random effects (method of moments), 2-sided *P*-value, Z-distribution, rate, and 95% CIs, were conducted on both quantitative and categorical variables (including follow-up duration, female ratio, mean age, year the study started, unipolar ratio of HA prosthesis, ratio of retained HA stem, surgical approach, head size, HA prosthesis age, inclusion of infected cases, use of constrained prosthesis and dual mobility cups, rate of acetabular erosion cases, and quality of included studies). To address potential study bias, Egger's linear regression test was employed, applying the trim-and-fill method for correction where significant high publication bias was detected (*P*-value < .05) [41]. All analyses were performed using the comprehensive meta-analysis software (CMA, version 3.3).

Results

Study characteristics and quality assessment

All of the included studies had retrospective designs. Only 8 (28%) studies had control groups. Studies were primarily conducted outside the United States (n = 19, 68%). The mean age of participants was 67.2 years; 35% (n = 1425; numbers are provided from the available data) of patients were male; pooled follow-up of studies was 4 years; pooled HA prosthesis age was 6.7 years; pooled operation time was 185 minutes; and pooled estimated blood loss was 622 cc. In the included articles, it was reported that 43% (n = 264) of the hip arthroplasties (HAs) used a cemented fixation type, while the remaining 57% (n = 342) opted for a cementless approach. The type of HA prosthesis in the articles was unipolar in 33% (n = 693) and bipolar in 67% (n = 1414) of prostheses. Reasons for conversion in the included studies were: acetabular erosion or protrusion (40%, n = 661), stem loosening (26%, n = 430), acetabular erosion and stem loosening (16.5%, n = 272), instability (6.5%, n = 107), PPFX (4%, n = 66), infection (3%, n = 50), implant breakage (1%, n = 16), and unknown reasons (3%, n = 50). All 28 studies were peer-reviewed journal articles written in the English language. Quality assessment of included studies is available in Table 1. Nineteen studies had "Good" quality; 5 had "Fair" quality; 4 had "Poor" quality. The characteristics and preoperative data of the studies are detailed in Table 2. The surgical data of the studies are detailed in Table 3. A summary of reported outcomes is available in Table 4.

Q1

Regarding the first research question on the effect of conversion in failed cases on HHS, data from 15 studies demonstrated a significant improvement in postoperative HHS. The pooled latest HHS among included studies was 85.8 (range: 75-96). A comparison of the preoperation HHS and the latest follow-up HHS shows a mean difference of 39.1 (range: 10.7-57.3; Fig. 2). The heterogeneity was high (I^2 = 99%), therefore a sensitivity analysis was conducted. Sensitivity analysis showed the mean change of HHS was consistent (range of summary MDs: 38.0-40.8). A meta-regression was conducted to find any causes of heterogeneity among the characteristics of studies. It was found that preoperative HHS status has a significant impact on the mean HHS difference (*P* < .001; Fig. 3).

Q2

Addressing the second research question about the complication rates following cTHA, the meta-analyses of outcomes reveal

Table 1
NIH quality assessment tool for case series studies.

Author, year	1	2	3	4	5	6	7	8	9	Quality rating
Bayam, 2019 [11]	Y	Y	NR	Y	Y	N	Y	Y	Y	Fair
Bhosale, 2012 [28]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Bilgen, 2000 [34]	Y	Y	NR	N	Y	N	N	N	Y	Poor
Carulli, 2016 [25]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Chalmers, 2017 [21]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Chalmers, 2017-2 [21]	N	Y	NR	Y	Y	Y	Y	N	Y	Fair
Chavan, 2017 [20]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Diwanji, 2008 [31]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Fichman, 2015 [27]	Y	Y	NR	N	Y	Y	Y	Y	Y	Fair
Figved, 2007 [32]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Hernandez, 2019 [10]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Huang, 2019 [9]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Kaku, 2017 [19]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Llinas, 1991 [37]	N	Y	NR	Y	Y	Y	Y	N	N	Poor
Morsi, 2016 [24]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Nabil, 2015 [26]	Y	Y	Y	Y	Y	N	N	Y	Y	Good
Ofa, 2021 [7]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Good
Pankaj, 2008 [30]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Park, 2018 [12]	Y	Y	NR	N	N	Y	N	N	Y	Poor
Rajeev, 2016 [23]	N	Y	Y	Y	Y	Y	Y	Y	Y	Good
Rajput, 2022 [15]	Y	Y	Y	Y	Y	N	Y	Y	Y	Good
Sah, 2008 [29]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Salama, 2016 [22]	Y	Y	NR	Y	Y	N	N	Y	Y	Fair
Sambandam, 2022 [8]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Sarpong, 2019 [16,17]	Y	Y	NR	Y	Y	Y	Y	Y	Y	Good
Sharkey, 1998 [36]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Good
Sierra, 2002 [33]	Y	Y	NR	N	Y	N	Y	Y	Y	Fair
Taheriazam, 2017 [18]	N	Y	NR	Y	N	N	Y	Y	Y	Poor

NIH, national institute of health.

Table 2
Characteristics and preoperative data of conversion surgery.

Author, year	Follow-up	Sex (male:female)	Age	Number of hips	Start year	Reason for index revision	Country
Bayam, 2019 [11]	6.3 (2-14)	37:5	70 (51-80)	42	2005	26 acetabular erosion 10 femoral loosening 1 periprosthetic fracture 10 deep infection 6 unknown	Turkey
Bhosale, 2012 [28]	8 (5-13)	35:54	68 (57-91)	89	1986	6 Periprosthetic fractures 8 Implant breakage 36 femoral loosening 19 acetabular erosion and protrusion 6 recurrent dislocation 2 Improper positioning 12 Painful hip	India
Bilgen, 2000 [34]	2.6 (1-4.5)	2:18	59 (30-75)	18	1992	Pain	Turkey
Carulli, 2016 [25]	3.8 (1-6)	13:18	75.4 (71-76)	31	2006	Recurrent dislocation	Italy
Chalmers, 2017 [21]	3 (2-5)	4:12	75 (57-93)	16	2011	9 acetabular erosion 7 Recurrent dislocation	US
Chalmers, 2017-2 [21]	3 (2-5)	7:6	69 (49-87)	13	2011	6 acetabular erosion 7 femoral loosening	US
Chavan, 2017 [20]	3.4 (1.5-7)	8:14	61 (32-79)	22	2010	5 acetabular erosion 8 femoral loosening 2 femoral loosening and erosion 1 PJI 2 periprosthetic fx	India
Diwanji, 2008 [31]	7.2 (3-16)	12:13	59.2 (25-82)	25	1990	13 acetabular erosion 4 periprosthetic fx 8 femoral loosening and erosion	Korea
Fichman, 2015 [27]	3.9 (1-12)	14:32	68.3 (23-95)	46	2002	25 acetabular erosion 13 femoral loosening 7 recurrent dislocation 1 deep infection	Canada
Figved, 2007 [32]	5.1			595	1987		Norway
Hernandez, 2019 [10]	9.3 (0-28)	108:281	72	389	1985	143 acetabular erosion 121 femoral loosening 97 femoral loosening and erosion 13 periprosthetic fracture 4 recurrent dislocation 11 deep infection	US
Huang, 2019 [9]	6.2 (5-7.8)	15:32	86 (83-89)	47	2008		Taiwan
Kaku, 2017 [19]	5.2 (1-18)	10:44	67.7 (47-86)	61	1996	55 migration of the outer cup component 4 disassembly of the bipolar cup 2 recurrent dislocation	Japan
Llinas, 1991 [37]	7.4	33:66	63	99	1970		US
Morsi, 2016 [24]	6.2 (4-13)	101:116	59.4 (54-79)	217	1997	109 acetabular erosion 45 femoral loosening 46 femoral loosening and erosion 9 recurrent dislocation 8 deep infection	Egypt
Nabil, 2015 [26]	3	22:20	59 (46-69)	42	2008	42 acetabular erosion	Egypt
Ofa, 2021 [7]	2	740:1450		2190	2010		US
Pankaj, 2008 [30]	6.4 (2-9)	14:30	62 (42-75)	44	1998	14 acetabular erosion 15 femoral loosening 3 recurrent dislocation 6 deep infection 2 periprosthetic fracture 4 Prosthesis breakage	India
Park, 2018 [12]	6.2 (2-11.5)	22:26	68.9 (28-80)	48	1998		Korea

						19 acetabular erosion 13 femoral loosening and erosion 4 recurrent dislocation 12 periprosthetic fracture	
Rajeev, 2016 [23]	2	4:6	85.4 (76-91)	10	2008	10 recurrent dislocation	UK
Rajput, 2022 [15]	5	12:16	61.1	28	2004	7 acetabular erosion 14 femoral loosening 2 recurrent dislocation 5 periprosthetic fracture	Pakistan
Sah, 2008 [29]	5 (1-11)	37:52	64.4 (30-91)	89	1994	52 acetabular erosion 34 femoral loosening 3 recurrent dislocation	US
Salama, 2016 [22]	3.5 (2.5-6)	24:16	58 (48-68)	40	2008	25 femoral loosening 5 prosthesis breakage 10 periprosthetic fracture	Egypt
Sambandam, 2022 [8]	2			71	2010		US
Sarpong, 2019 [16,17]	2.8 (2-9)	21:39	74.5 (49-94)	60	2007	20 acetabular erosion 27 femoral loosening 7 periprosthetic fracture 5 recurrent dislocation 1 LLD	US
Sharkey, 1998 [36]	2.9 (2-6)	11:34	65 (32-85)	45	1989		US
Sierra, 2002 [33]	7.1 (5-15)	24:108	68.4	132	1985	46 acetabular erosion 22 femoral loosening 54 femoral loosening and erosion 3 deep infection 2 periprosthetic fracture 5 unknown	US
Taheriazam, 2017 [18]	3.5 (2.5-5)	90:48	64 (25-87)	138	2009	42 acetabular erosion 54 femoral loosening 20 femoral loosening and erosion 10 deep infection 12 dislocation	Iran
Warwick, 1998 [35]		5:51	74 (46-87)	56	1980	26 acetabular erosion 21 femoral loosening 5 femoral loosening and erosion 1 deep infection 1 periprosthetic fracture 2 unknown	UK

Table 3
Surgical data for conversion surgery.

Author, year	HA fixation	HA type	Stem retained	Approach	Head size	HA age	Special type of THA	Operation time	Blood loss	DVT	Intraoperative fractures
Bayam, 2019 [11]		37 Uni 5 Bi		TTC	22 mm						
Bhosale, 2012 [28]	CL	Uni	0	PL		4.8					
Bilgen, 2000 [34]				L (2 TTC)		7.3					
Carulli, 2016 [25]		Bi		L	28 mm	3.2	DM-Cup	57.8	210	3	0
Chalmers, 2017 [21]	14 C 2 CL	BI	2		45.4 mm	6	DM-Cup			0	1
Chalmers, 2017-2 [21]	9 C 4CL	Bi	8		37.5 mm	10	Large head THA			1	0
Chavan, 2017 [20]		15 Bi 7 Uni		PL (5 TTC)		4.5					
Diwanji, 2008 [31]	C	Bi	12	PL		4.2				0	0
Fichman, 2015 [27]		Bi	25	PL (22 TTC)	12 < 28 mm 25 32 mm 9 > 36 mm	6.1					
Figved, 2007 [32]		Bi	122								35
Hernandez, 2019 [10]		Bi	72		266 28 mm 75 32 mm 48 > 32 mm			203			38
Huang, 2019 [9]		Uni	0	AL				153	522	0	0
Kaku, 2017 [19]	12 C 49 CL	Bi	61	PL	28.5 mm	14.9	31 Cemented cup with Kerboull-type plate	213	352	2	1
Llinas, 1991 [37]	CL	Uni	0	81 L(TTC) 25 PL	81 22 mm 25 28 mm						
Morsi, 2016 [24]		78 Uni 139 Bi	31	L						7	0
Nabil, 2015 [26]		Bi	42	L			Cementless multihole mega cups				
Pankaj, 2008 [30]		32 Uni 12 Bi	0	PL(4 TTC)						2	7
Park, 2018 [12]		Bi	23	PL	22 28 mm 5 32 mm 2 36 mm 19 > 40 mm	6.7				0	
Rajeev, 2016 [23]	C	Uni	0				Constrained captive acetabular cup			0	
Rajput, 2022 [15]		Uni	0	L							
Sah, 2008 [29]			28	PL	30.6	11.2					
Salama, 2016 [22]		28 Uni 12 Bi		L			Cementless long stem	150	1000	1	
Sarpong, 2019 [16,17]	31C 29CL	48 Uni 12 Bi	15		34.9	7.4		148	587		
Sharkey, 1998 [36]	16 C 29 CL	14 Uni 31 Bi	0			3.7					
Sierra, 2002 [33]	102 C 30 CL	120 Uni 12 Bi				4.9		199		1	12
Taheriazam, 2017 [18]				L(30 TTC)							
Warwick, 1998 [35]	45 C 11 CL	Uni	0			3.9		160	1000	3	

DVT, deep vein thrombosis.

Table 4
Outcomes of conversion surgery: N (%).

Author, year	PJI	Dislocation	Periprosthetic fractures	Stem loosening	Acetabular loosening	Overall revision	Reason for re-revision
Bayam, 2019 [11]	3 (7)	4 (9)	0 (0)			2 (4)	
Bhosale, 2012 [28]	2 (2)	1 (1)	0 (0)			4 (4)	2 deep infections 2 loosening
Bilgen, 2000 [34]						0 (0)	
Carulli, 2016 [25]	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Chalmers, 2017 [21]	2 (12)	0 (0)		0 (0)	0 (0)	2 (12)	2 deep infections
Chalmers, 2017-2 [21]	0 (0)	1 (7)		0 (0)	0 (0)	1 (7)	1 dislocation
Chavan, 2017 [20]				0 (0)	0 (0)	0 (0)	
Diwanji, 2008 [31]	0 (0)	4 (16)	0 (0)	0 (0)	1 (4)	1 (4)	1 acetabular loosening
Fichman, 2015 [27]	1 (2)	2 (4)	0 (0)	1 (2)	1 (2)	5 (10)	2 recurrent dislocations 1 acetabular loosening 1 femoral loosening 1 deep infection
Figved, 2007 [32]	5 (1)	19 (3)	7 (1)	26 (4)	9 (1)	70 (11)	19 recurrent dislocations 9 acetabular loosening 26 femoral loosening 5 deep infection 7 fractures 4 other causes
Hernandez, 2019 [10]	8 (2)	34 (8)	24 (6)	20 (5)	9 (2)	67 (16)	12 recurrent dislocations 4 acetabular loosening 15 femoral loosening 5 both component loosening 8 deep infection 16 fractures 7 other causes
Huang, 2019 [9]	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Kaku, 2017 [19]	0 (0)	1 (1)	2 (3)	0 (0)	0 (0)	2 (3)	2 fractures
Llinas, 1991 [37]				4 (4)	5 (5)	6 (6)	2 acetabular loosening 1 femoral loosening 3 both component loosening
Morsi, 2016 [24]	1 (0)	12 (5)	0 (0)			15 (7)	
Nabil, 2015 [26]	0 (0)	2 (4)	0 (0)	0 (0)	0 (0)	0 (0)	
Ofa, 2021 [7]	211 (9)	16 (1)	51 (2)			32 (1)	
Pankaj, 2008 [30]	0 (0)	1 (2)	0 (0)	1 (2)	0 (0)	1 (2)	1 femoral loosening
Park, 2018 [12]	0 (0)	2 (4)	0 (0)	0 (0)	1 (2)	1 (2)	1 acetabular loosening
Rajeev, 2016 [23]	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Rajput, 2022 [15]		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Sah, 2008 [29]		20 (22)				9 (10)	5 recurrent dislocations 4 unknown
Salama, 2016 [22]	0 (0)	0 (0)	1 (2)	0 (0)	0 (0)	1 (2)	1 stem breakage
Sambandam, 2022 [8]						17 (23)	
Sarpong, 2019 [16,17]	1 (2)	4 (7)	0 (0)	1 (2)	0 (0)	6 (10)	
Sharkey, 1998 [36]	0 (0)		1 (2)	1 (2)	0 (0)	2 (4)	1 stem loosening 1 trochanteric nonunion
Sierra, 2002 [33]	1 (1)	13 (10)	4 (3)	8 (6)	1 (1)	14 (10)	9 aseptic loosening 2 dislocation 1 deep infection 2 fracture
Taheriazam, 2017 [18]		6 (4)					
Warwick, 1998 [35]	1 (2)	6 (11)	3 (6)	1 (2)	1 (2)		

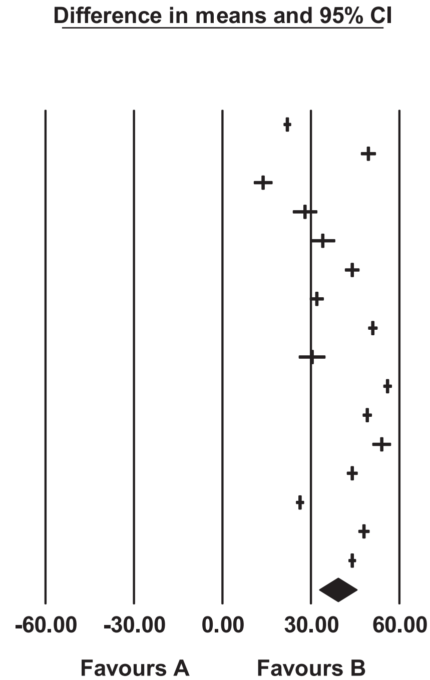
varying rates of complications: PJI rate was observed to be 2.8%, PPFX rate was 2.2%, the dislocation rate was 4.2%, the acetabular loosening rate was 1.9%, and overall revision rate was 4.7%. The rate of stem loosening, which was correlated with follow-up duration, was calculated as 0.0027 per person-years. A comprehensive account of these complications is available in Table 5.

The heterogeneity was high among PJI rates, dislocations, and overall revision rates. Sensitivity analysis showed that the study by Ofa et al. impacts the dislocation rate [7]; therefore, we removed that study, and the dislocation rate increased to 5.6% (95% CI: 3.4-8.9%; I^2 = 60%). A meta-regression was conducted to find any causes of remaining heterogeneity among the characteristics of studies. It was found that studies from the United States reported higher dislocation rates compared to other countries ($P < .001$). We assessed publication bias using the Egger's test, which showed a high level of publication bias. Therefore, we used the trim and fill method to reduce publication bias in regard to dislocation rate. After trimming 7 studies using the trim and fill method, the dislocation rate was estimated to be 7.6% (95% CI: 4.9-11.5%; Table 5).

Sensitivity analysis showed that the study by Morsi et al. impacts the PJI rate [24]; therefore, we removed that study, and the PJI rate increased to 3.8% (95% CI: 1.9-6.5%; I2 = 44%). A meta-regression was conducted to find any causes of remaining heterogeneity among the characteristics of studies. No factor was influential on PJI rates ($P > .05$). We assessed publication bias using the Egger's test, which showed a high level of publication bias. Therefore, we used the trim and fill method to reduce publication bias in regard to PJI rate. After trimming 7 studies using the trim and fill method, the PJI rates were estimated to be 6.4% (95% CI: 3.7-10.8%; Table 5).

Meta Analysis

Study name	Difference in means	Lower limit	Upper limit	p-Value
Bhosale, 2012	22.000	20.792	23.208	0.000
Bilgen, 2000	49.500	47.020	51.980	0.000
Carulli, 2016	13.800	10.702	16.898	0.000
Chalmers, 2017	28.000	23.914	32.086	0.000
Chalmers-2, 2017	34.000	29.826	38.174	0.000
Diwanji, 2008	44.000	41.603	46.397	0.000
Fichman, 2015	32.000	29.682	34.318	0.000
Huang, 2019	51.000	49.496	52.504	0.000
Kaku, 2017	30.400	25.953	34.847	0.000
Morsi, 2016	56.000	54.607	57.393	0.000
Nabil, 2015	49.100	47.610	50.590	0.000
Pankaj, 2008	54.000	50.906	57.094	0.000
Park, 2018	44.000	42.224	45.776	0.000
Sah, 2008	26.300	24.989	27.611	0.000
Salama, 2016	48.000	46.177	49.823	0.000
Taheriazam, 2017	44.000	42.786	45.214	0.000
	39.171	32.869	45.473	0.000



Meta Analysis

Figure 2. Mean difference of HHS following cTHA.

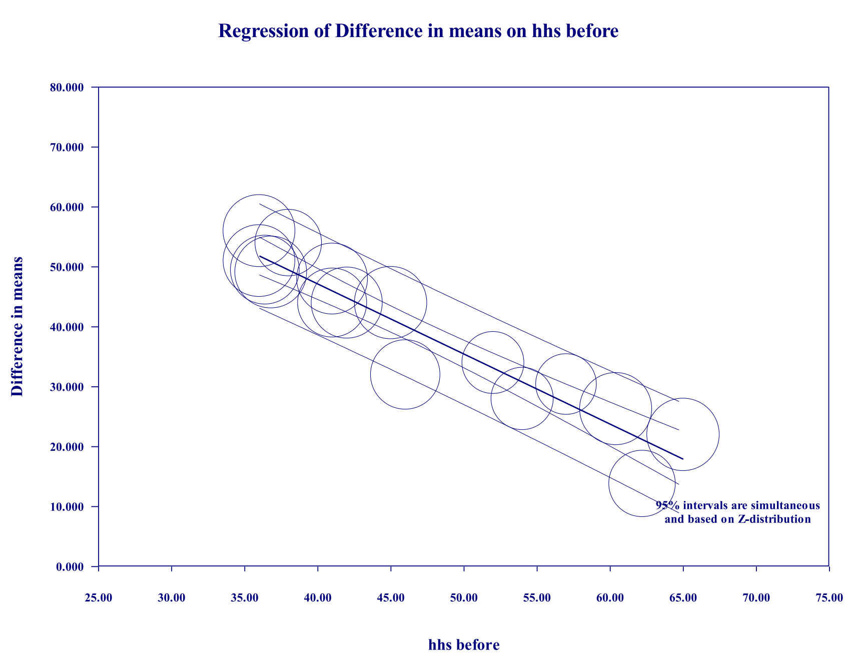


Figure 3. Meta-regression of preoperative HHS impacting HHS difference post-cTHA.

Table 5
Summary of meta-analyses of studies started after 1990.

Complications	Number of studies	Random effect meta-analysis (95% CI)	I^2 heterogenicity	Egger *P*-value	After trimming (95% CI) (number of trimmed studies)
PJI	16	0.028 (0.014-0.054)	56%	<.001	0.064 (0.037-0.108) (7 studies)
Periprosthetic fracture	15	0.022 (0.017-0.028)	0.0%	.09	–
Dislocation	19	0.042 (0.021-0.082)	85%	.003	0.076 (0.049-0.115) (7 studies)
Stem loosening[a]	15	0.0027 per person-year (0.0006-0.0047)	0.0%	.08	–
Acetabular loosening	15	0.019 (0.010-0.036)	0.0%	.13	–
Overall revision	21	0.047 (0.026-0.084)	82%	<.001	0.087 (0.059-0.128) (8 studies)
HHS mean difference	15	39.17 (32.86-45.47)	99%	.92	–

[a] Rate of stem loosening is calculated per person-years at a mean follow-up of 6 years.

Sensitivity analysis showed that the study by Ofa et al. impacts the overall revision rate [7]; therefore, we removed that study and the overall revision rate increased to 6.3% (95% CI: 4.1-9.5%; I2 = 51%). A meta-regression was conducted to find any causes of remaining heterogeneity among the characteristics of studies. It was found that studies from the USA reported higher overall revision rates compared to other countries ($P < .001$). We assessed publication bias using Egger's test, which showed a high level of publication bias. Therefore, we used the trim and fill method to reduce publication bias in regard to overall revision rate. After trimming 8 studies, the overall revision rate was estimated to be 8.7% (95% CI: 5.9-12.8%; Table 5).

Q3

In regard to the third question, considering the comparative studies that explored complication rates between cTHA, rTHA, and pTHA, 4 studies compared cTHA to rTHA and 4 studies compared cTHA to pTHA. Findings suggest a variance in complication rates among these surgeries, detailed in Table 6. The majority of the studies indicated that cTHA is associated with higher complication rates and a greater likelihood of overall revision compared to pTHA.

Table 6
Main findings of comparative studies.

Author, year	Cohort (n) vs control (n)	Findings
Ofa, 2021 [7]	Conversion THA (2190) vs Primary THA (2190)	The conversion group showed significantly higher rates of dislocations, PJIs, PPFX, aseptic loosening, and overall revision 2 y postsurgery.
Sambandam, 2022 [8]	Conversion THA (71) vs Primary THA (117939)	The conversion group showed significantly higher rates of overall revisions 2 y postsurgery.
Sarpong, 2019 [16,17]	Conversion THA (60) vs Primary THA (65)	The conversion group showed a higher dislocation rate with no significant difference in PJI rates, PPFX, aseptic loosening, or 2-y revision rate.
Figved, 2007 [32]	Conversion THA (595) vs Primary THA (74865)	The conversion group showed significantly higher rates of overall revisions 5 y postsurgery.
Sarpong, 2019 [16,17]	Conversion THA (60) vs Revision THA (60)	The conversion group had lower total complications (PJI + dislocation + PPFX + aseptic loosening) at 2 y. When comparing each complication, no significant difference was detected.
Fichman, 2015 [27]	Conversion THA (46) vs Revision THA (46)	No significant difference in complication or revision rates or HHS.
Sah, 2008 [29]	Conversion THA (89) vs Revision THA (115)	The conversion group showed higher dislocation rates.
Figved, 2007 [32]	Conversion THA (595) vs Revision THA (3081)	The conversion group showed lower 5-y overall revision rates.

In comparisons between cTHA and rTHA, 2 studies found that cTHA resulted in fewer complications, one study observed no significant differences, and another reported an increased risk of dislocation with cTHA.

Discussion

Hip HA has played a role in improving the quality of life for patients with femoral neck fractures [42]. This study investigates the effectiveness of cTHA in cases where previous HAs have failed. This is important due to the growing number of elderly people worldwide and the increasing incidence of femoral neck fractures. By analyzing 28 retrospective studies, the research provides a detailed view on the efficacy, postoperative outcomes, and complication rates of cTHA.

To answer the first question about the impact of cTHA on postoperative HHS, there was a significant improvement in the HHS scores after the surgery. The average latest HHS score across the studies was 85.8. The difference between the preoperative and postoperative HHS scores was 39.1, showing a major improvement in patient outcomes after cTHA. These results are consistent with previous research, which also shows significant improvements in HHS after cTHA, highlighting its role in enhancing patient mobility and quality of life [43,44]. Additionally, the results indicated that patients with lower initial mobility and quality of life saw greater benefits from cTHA.

Regarding the second research question, we analyzed data from 4699 hips with an average follow-up of 4 years. The findings reveal a variety of complications: PJI occurred in 6.4% of cases, PPFX in 2.2%, dislocation in 7.6%, stem loosening in 1.6%, acetabular loosening in 1.9%, and an overall re-revision rate of 8.7%. When comparing these rates with those found in previous studies, we found several factors that could affect the outcomes (Table 7). These include surgical techniques, patient demographics, health-care settings, types of prosthetics used, and regional health-care disparities.

The comparison between cTHA and pTHA shows a consistent trend across various studies, indicating that patients undergoing cTHA generally experience more challenges postoperatively [7,8,17,32]. However, when comparing cTHA to rTHA, the outcomes are more varied. A notable study by Sarpong et al. found that while the cTHA group had a lower overall complication rate (including PJI, dislocation, PPFX, and aseptic loosening) at 2 years, there was no significant difference when each complication was examined separately [17]. Similarly, Fichman et al. reported no significant differences in complication rates, revision rates, or HHS scores between the conversion and revision groups [27]. Yet, some studies, like those by Sah et al. and Figved et al., show differing results, such as a higher dislocation rate in the conversion group and a lower 5-year revision rate, respectively [29,32]. These mixed results suggest that factors like surgical techniques, patient demographics, or the

Table 7
Comparison of our study complications to recent large population articles in the literature.

Study	Type of study	Number of hips	Mean follow-up	PJI	PPFX	Dislocation	Stem loosening	Acetabular loosening	Overall re-revision
Current study	Systematic review of cTHA of HA	4699	4	6.4%	2.2%	7.6%	1.6%	1.9%	8.7%
Daliri et al. [44] (2023)	Systematic review of cTHA of hip fusion	2286	NR	3%	4%	2%	5%		12%
Kenny et al. [45] (2019)[a]	Systematic review of rTHA	9952	NR	2.9%	0.5%	3.8%	3.0%		13.2%
Goldman et al. [46] (2019)[a]	Aseptic rTHA in one institution	2589	6	0.5%	0.9%	4.2%	0.9%	0.7%	8.1%
Poursalehian et al. [47] (2023)	Systematic review of isolated acetabular rTHA	3497	9.3	NR	NR	5.7%	1.7%	NR	8.8%

NR, not reported.
[a] These 2 studies reported the infections, fractures, dislocations, and loosening leading to re-revision.

type of prosthetic used may significantly influence the outcomes after these surgeries.

Limitations

Our study does have several potential limitations that need acknowledgment. Many of the included studies are retrospective, which, while informative, often contain biases that are difficult to completely control. Additionally, only 28% of the studies included control groups, which may limit the comparative validity of our findings. The quality of the studies varies, with some categorized as "Poor," which could restrict the reliability of our pooled data and subsequent analyses. The high heterogeneity in some results necessitated the use of a random-effects model and conducting sensitivity analyses, which may not fully adjust for differences among the studies. Extracting data from studies with diverse designs and methodological qualities might also introduce bias into our results. Furthermore, inherent biases and limitations in the original studies, such as selection bias, are also limitations of the current literature in this regard.

Implications of the results for practice and future research

The findings from this study clearly demonstrate that cTHA is a viable and often beneficial option for patients dealing with the failure of a previous HA, showing improvements in postoperative HHS scores and notable, though varied, complication rates. The complexities, diverse outcomes, and multifaceted nature of cTHA outcomes highlight the need for a tailored, patient-centered approach in surgical planning and management. Future research in this field should focus on the details of surgical protocols, prosthesis selection, and preoperative and postoperative management strategies.

Conclusions

Our study looked into the outcomes of cTHA after a failed HA. We found that patients generally experienced improved HHS following cTHA and also encountered a variety of complications. Our findings underscore the need for surgeons to approach each case individually, taking into account many factors, from surgical techniques to patient health and health-care settings.

Conflicts of interest

The authors declare there are no conflicts of interest.
For full disclosure statements refer to https://doi.org/10.1016/j.artd.2024.101459.

CRediT authorship contribution statement

Mohammad Poursalehian: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Ali Hassanzadeh:** Data curation. **Mohadeseh Lotfi:** Writing – original draft, Data curation. **Seyed Mohammad Javad Mortazavi:** Writing – review & editing, Supervision.

Declaration of generative AI and AI-assisted technologies in the writing process

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Supplementary Table 1
P-values for meta-regression and subgroup analyses.

P-value	PJI	Dislocation	Overall revision
Follow-up	0.14	0.10	0.18
Sex	0.90	0.62	0.55
Age	0.12	0.76	0.74
Start year	0.12	0.14	0.11
Country	0.12	**0.00**[a]	**0.01**[a]
Number of erosion cases	0.40	0.10	0.98
HA type (unipolar vs bipolar)	0.84	0.77	0.30
Retained stem	0.97	0.82	0.77
Approach (PL vs L)	0.33	0.68	0.49
Head size (<32 mm vs ≥ 32 mm)	0.19	0.52	0.82
HA age	0.76	0.85	0.48
Conversion in infected cases (Yes vs No)	0.58	0.80	0.57
Special type of THA (Yes vs No)	0.88	0.20	0.22
Quality	0.90	0.22	0.10

[a] *P*-values less than .05 are written in bold.