



Patients with femoral neck fractures treated by bipolar hemiarthroplasty have superior to unipolar hip function and lower erosion rates and pain: a systematic review and meta-analysis of randomized controlled studies

Kyriakos Papavasiliou¹ · Nifon K. Gkekas¹ · Dimitrios Stamiris¹ · Ioannis Pantekidis² · Eleftherios Tsiridis¹

Received: 6 May 2022 / Accepted: 15 June 2022

© The Author(s), under exclusive licence to Springer-Verlag France SAS, part of Springer Nature 2022

Abstract

Purpose We assessed acetabular erosion, hip function, quality of life (QoL), pain, deep infection, mortality, re-operation and dislocation rates in patients with displaced femoral neck fractures (dFNFs) treated with unipolar versus bipolar hemiarthroplasty at different postoperative time points.

Methods Relevant Randomized Controlled Trials (RCTs) were identified, following comprehensive literature research in Medline, Cochrane Central and Scopus databases, from conception until August 31th, 2021 and analyzed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Results Database research retrieved 120 studies; sixteen met eligibility criteria, providing 1813 (1814 hips) evaluable patients. Acetabular erosion was significantly higher for unipolar group at 6 and 12 months ($p=0.02$ and $p=0.01$ respectively). Patients in the bipolar group presented significantly better hip function at 12 and 24 months ($p=0.02$ and $p=0.04$ respectively). Postoperative pain was significantly less in the bipolar group at 12, 24 and 48 months ($p=0.01$). No statistically significant differences were found regarding the postoperative rates of deep infection, mortality, re-operation and dislocation.

Conclusion This study showed that patients with dFNFs treated with bipolar hemiarthroplasty have lower acetabular erosion rates at 6 and 12 months postoperatively, better hip function at 12 and 24 months, better QoL and less pain, when compared with unipolar. No statistically significant difference could be established regarding deep infection, mortality, re-operation and dislocation rates.

Keywords Bipolar hemiarthroplasty · Unipolar hemiarthroplasty · Displaced femoral neck fracture · Elderly · Postoperative results

✉ Kyriakos Papavasiliou
papavasiliou.kyriakos@gmail.com

Nifon K. Gkekas
nifwn_gekas@hotmail.com

Dimitrios Stamiris
dimitris.stamiris@hotmail.com

Ioannis Pantekidis
pantekidis.giannis@gmail.com

Eleftherios Tsiridis
tsiridisehs@gmail.com

¹ Academic Orthopaedic Unit, Papageorgiou General Hospital, School of Medicine, Aristotle University of Thessaloniki, Thessaloniki Ring Road West, 564 03 Nea Efkarpia, Thessaloniki, Greece

² 3rd Orthopaedic Department, HYGEIA Hospital, Erythrou Stavrou 4, Marousi, 15123 Athens, Greece

Introduction

Femoral neck fractures are common injuries among the elderly [1], associated with increased mortality [2]. Hip hemiarthroplasty, with either a cemented or an uncemented stem, is considered to be the standard of care for the treatment of displaced femoral neck fractures (dFNFs) in these patients [3–8]. Bipolar hemiarthroplasty has a theoretical advantage over the unipolar, since it was conceived and designed to achieve increased mobility (hence lower acetabular erosion postoperatively) and decreased dislocation rates [9, 10]. However, it was shown that gradually the inner articulation stops functioning and becomes stiff, hence minimizing—if not eliminating—its main advantage [11, 12]. Moreover, the higher cost of the

bipolar prosthesis raises the question whether this difference in costs translates into better functional outcomes and quality of life [13, 14].

The selection of a unipolar or a bipolar prosthesis remains still a controversial issue [6, 8], despite the numerous attempts by studies and several meta-analyses to evaluate and compare the clinical outcomes between these two treatments [6]. The aim of this study was to perform a meta-analysis including all available randomized controlled trials (RCTs) studies to determine at all available different postoperative time points: (a) whether there were any significant differences in the erosion rates and (b) the postoperative functional outcomes of the patients, regarding hip function, postoperative pain, range of hip motion (ROM), deep infection, mortality, dislocation and re-operation rates and quality of life (QoL).

Materials and methods

Guidelines followed

This systematic review was performed by following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [15], and it was registered in the Prospective Register of Systematic Reviews System (PROSPERO ID: CRD42021255275). A flow diagram of the studies is presented in Fig. 1. A completed PRISMA checklist can be found as Supplementary Table 1.

Search strategy

This systematic review was conducted according to the “PICO” model for clinical questions: (1) Population: patients with a displaced femoral neck fracture treated with hemiarthroplasty; (2) Intervention: hip hemiarthroplasty with the

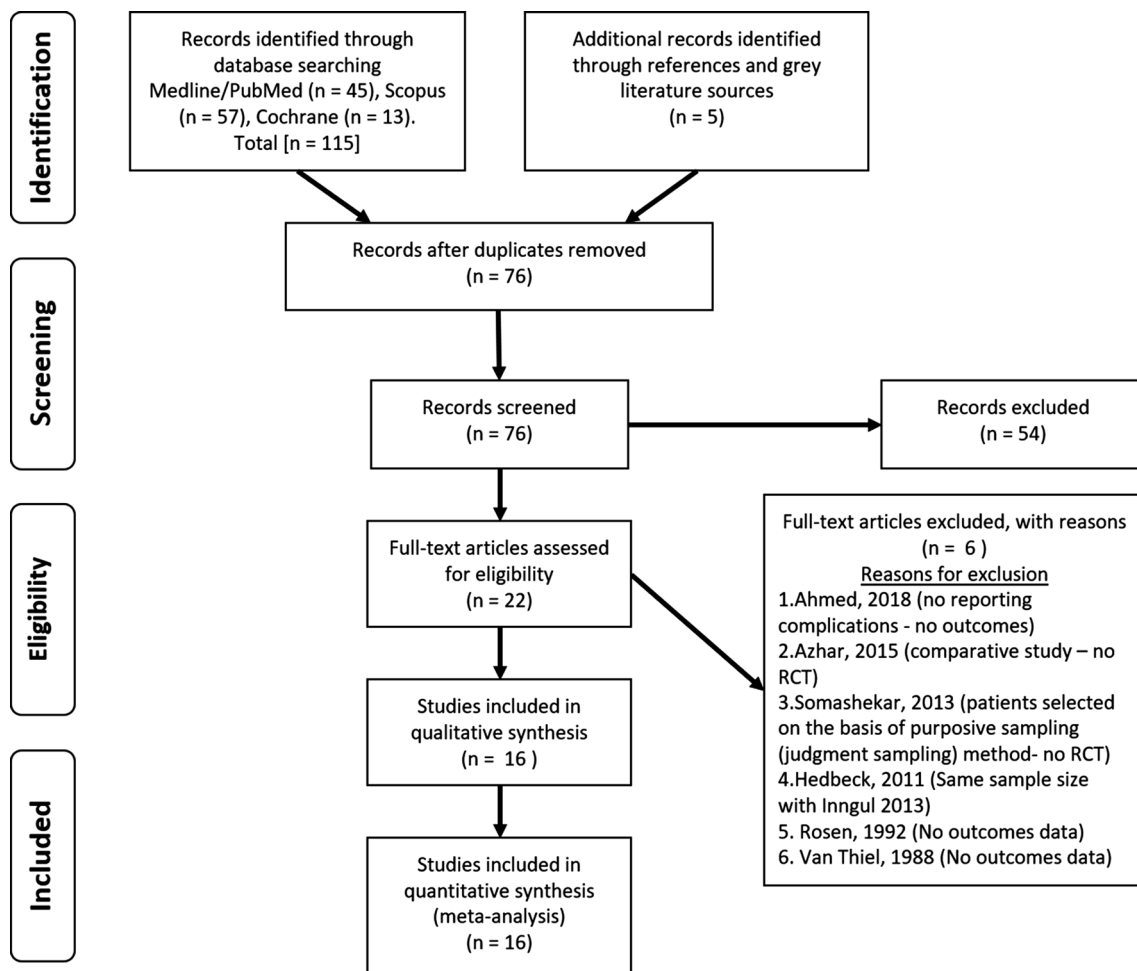


Fig. 1 The PRISMA 2009 flow diagram of the studies that were initially identified, with all the steps leading to the final inclusion of 16 studies in this meta-analysis

use of a unipolar head; (3) Comparison group: hip hemiarthroplasty with the use of a bipolar head; (4) Outcome: functional scores (Harris Hip Score, 6 min walk test), quality of life scores (EQ-5D), complications (dislocation, acetabular erosion, loosening of prosthesis, periprosthetic fracture, deep infection, pain), re-operation rate, mortality.

Moreover, specific inclusion criteria were determined before the onset of the literature search: (1) only randomized controlled trials (RCTs) were to be included, (2) patients with a displaced femoral neck fracture, (3) studies providing sufficient information to complement 2×2 contingency tables on the investigated outcomes and (4) studies published in English.

Studies were excluded when: (1) data were in a non-extractable form, (2) patients had a previous hip pathology (malignant disease, infectious disease) and (3) case controls, cohorts' studies with no randomization.

To identify eligible studies, a systematic search was conducted in PubMed (MEDLINE), Scopus and Cochrane (CENTRAL) electronic databases, covering the period from conception until August 31st, 2021 (Supplementary Table 2). "Grey literature" was searched using relevant websites, such as <http://www.opengrey.eu>, <http://greylib.org>, <http://apps.who.int/trialsearch/default.aspx>, <http://www.isrctn.com/>, and <https://clinicaltrials.gov>. The main search was completed independently by three investigators (NKG, DS and IP) who checked all available publications. Any discrepancy was resolved by the consultation of another investigator (KP).

Data extraction

Three researchers (NKG, DS and IP) reviewed all eligible studies. The following data were extracted and recorded: (1) first author; (2) year of publication; (3) country in which the study was conducted; (4) study duration (5) total number of participants; (6) number of participants with unipolar procedure; (7) number of participants with bipolar procedure; (8) postoperative complications; (9) functional scores; (10) reoperation rate; (11) mortality. Moreover, information for each study group after the surgery was recorded regarding sample size, follow-up (in months), mean age (\pm SD) of the participants, gender proportion, surgical approach, implant fixation method and the type of implant used.

Data evaluating the functional status of the operated hip, such as Harris Hip Score (HHS) [16] modified HHS [17], six minutes' walk test, postoperative pain and postoperative range of motion (ROM), were also recorded and further analyzed. Quality of life following unipolar or bipolar hip hemiarthroplasty was also evaluated using available data from the included studies, in particular EQ-5D index score [18].

Finally, all complications concerning the operated hip, such as dislocation, acetabular erosion, loosening of the

prosthesis, periprosthetic fracture, deep infection and reoperation, were also recorded.

Risk of bias and study quality assessment

The revised Cochrane risk-of-bias tool for RCTs (RoB 2.0) was implemented for each study risk of bias assessment. RoB 2.0 tool incorporates a fixed set of bias domains, focusing on different points of trial design, conduct and reporting. "Signaling questions," within each of the domains, aim to reveal study features prone to the risk of bias. Answering these questions generates a judgment value (low risk, high risk or some concerns). The investigator can also add personal judgment about the risk of bias for each domain, which is implemented to the overall risk value [19].

Statistical analysis

Heterogeneity was tested by the Cochrane Chi-square test. The degree of heterogeneity was quantified by the I^2 statistics. The true effect is expected to vary across various populations included in our meta-analysis, therefore, substantial to considerable between-studies heterogeneity was expected. Consequently, we incorporated the random effects model to address this issue. Associations were reported as Odds Ratio (OR) with 95% Confidence Intervals (CI) for quality measurements and mean difference for quantity measurements (\pm standard error) with 95% CI. A p value < 0.05 was considered as statistically significant. The publication bias was checked by Funnel plots and the Egger's test (p values > 0.1 indicated absence of publication bias). All analyses were performed with the software *Comprehensive MetaAnalysis V2*. Sensitivity analysis was performed by excluded increased risk of bias studies to test the strength and validity of pooled results.

Results

Study characteristics

The literature search yielded 120 studies, 22 of which were assessed as full-text articles. Based on our pre-established criteria, 6 articles were excluded due to the following reasons: (1) not available data on outcomes of interest ($n = 3$), (2) comparative study with no randomization ($n = 1$), (3) patients selected on the basis of purposive sampling (judgment sampling) method—no RCT ($n = 1$) and (4) use of the same cohort of patients with another study [8], already included in our analysis ($n = 1$). A flow diagram of the studies is presented in Fig. 1. Sixteen studies were eligible for quantitative analysis. A summary of the descriptive characteristics of the included studies is presented in Table 1.

Table 1 The characteristics of the studies which were included in the analysis

	General information						Unipolar group				Bipolar group			
	Author, year	Country	Hips (n)	Follow-up (months)	Type of approach		Hips (n)	Female (%)	Age Mean (SD)	Type of fixation	Hips (n)	Female (%)	Age Mean (SD)	Type of fixation
1	Figved et al. [7]	Norway	28	24	Posterior		14	72	80.5 (5.76)	Uncemented	14	72	79.7 (5.47)	Uncemented
2	Naser et al. [20]	India	140	12	Posterior		70	n/a	n/a	Uncemented	70	n/a	n/a	Uncemented
3	Naveen et al. [21]	India	100	12	Posterior		50	56	n/a	n/a	50	56	n/a	n/a
4	Vishwanath et al. [22]	India	112	12	Posterior		56	68	70.4	n/a	56	61	69.1	n/a
5	Balan et al. [23]	India	68	12	Posterior		34	59	73 (6.54)	n/a	34	45	76 (5.47)	Cemented
6	Kanto et al. [30]	Finland	175	60–96	Posterior		88	82	83.9 (6.5)	Cemented	87	83	81.7(6)	Cemented
7	Inngul et al. [11]	Sweden	120	48	Lateral		60	82	87.4	Cemented	60	70	85.5	Cemented
8	Mishra et al. [29]	Nepal	40	12	Posterior		20	60	n/a	n/a	20	55	n/a	n/a
9	Stoffel et al. [14]	Australia	261	12	Lateral		128	n/a	81.9 (8.8)	Cemented	133	n/a	82.9 (9.7)	Cemented
10	Abdelkhalik et al. [31]	Egypt	50	24–72	Posterior		25	n/a	n/a	15 cemented 10 uncemented	25	n/a	n/a	12 cemented 13 uncemented
11	Jeffcote et al. [13]	Australia	52	24	Lateral		27	78	81.4	Cemented	25	76	80.1	Cemented
12	Raia et al. [27]	USA	115	12	Posterior		60	68	81.8	Cemented	55	76	82.4	Cemented
13	Davison et al. [25]	UK	187	24–60	Lateral		90	79	75.2 (1.43)	Cemented	97	74	74.7 (2.0)	Cemented
14	Cornell et al. [28]	USA	48	6	Posterior		15	73	77.6(10)	Cemented	33	76	78 (8)	n/a
15	Calder et al. [26]	UK	250	24	Lateral		132	86	85(1.74)	Cemented	118	86	85 (1.74)	Cemented
16	Malhotra et al. [24]	India	68	9–47	Posterior		36	45	68	Uncemented	32	44	65	Uncemented

n number, SD standard deviation, n/a not available

The total number of participants was 1813 (1814 hips). The unipolar group consisted of 905 patients with a mean age of 78.84 years, while the bipolar group consisted of 908 patients (909 hips) with a mean age of 78.34 years.

Five studies were conducted in India [20–24], two in the UK [25, 26], two in the USA [27, 28], two in Australia [13, 14], one in Sweden [11], one in Nepal [29], one in Finland [30], one in Egypt [31] and one in Norway [9]. Additional information regarding follow-up, gender proportion, surgical approach, implant fixation method and the type of implant used is presented in Table 1.

Risk of bias assessment

Eleven studies were at low risk of bias regarding random sequence generation. Concerning allocation concealment, seven studies were at low risk of bias, whereas seven had some concerns and two were at high risk. With respect to blinding of participants and personnel and blinding of outcome assessment, eight studies were at low risk, seven had some concerns, and one had a high risk. Finally, all studies were at low risk of bias regarding selective reporting and incomplete outcome data. The risk-of-bias results are presented in Supplementary Table 3.

Acetabular erosion rates

The unipolar group had a significantly higher risk for the development of acetabular erosion, compared with the bipolar group, at both 6 and 12 months postoperatively (OR 3.84, 95% CI 1.21–12.19, $p=0.02$; I^2 0.0% and OR 3.67, 95% CI 1.40–9.62, $p=0.01$; I^2 0.0%). This risk, however, was not significantly different at 24 and 48 months (OR 2.51, 95% CI 0.93–6.75, $p=0.07$; I^2 0.0% and OR 2.55, 95% CI 0.95–6.80, $p=0.06$; I^2 0.0%). (Fig. 2, Table 2).

Postoperative hip function

Patients in the bipolar group presented significantly better hip function at 6, 12 and 24 months postoperatively, compared with the patients in the unipolar group (Figs. 3 and 4, Table 2). This was assessed by using the HHS and the six minutes’ walk test. Three studies [9, 23, 26] evaluated postoperative function by using the HHS and provided a numerical value, while four studies [20, 21, 23, 31] provided a stratified result using excellent/good/fair/poor as possible outcomes. Moreover, three studies evaluated hip function using the six minutes’ walk test [13, 14, 28]. Jeffcote et al. [13] reported a significant improvement at 3 months postoperatively for the bipolar group, but not

Acetabular Erosion

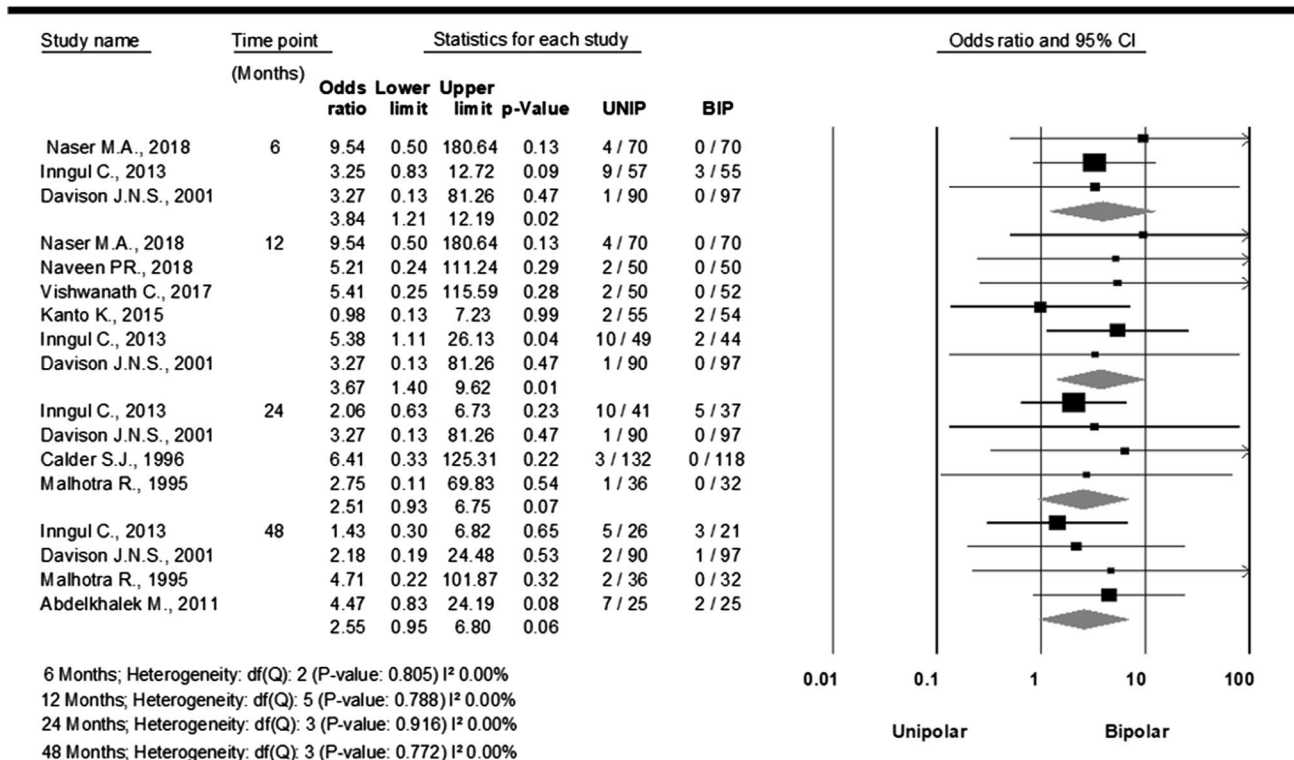


Fig. 2 Acetabular erosion at 6, 12, 24 and 48 months postoperatively

Table 2 The results of the meta-analysis

	Effect size Odds ratio or SMD (SD)	95% CI	<i>p</i> value	Heterogeneity
Acetabular erosion				
At 6 months	3.84	1.21–12.19	0.02	$I^2=0.0\%$, $p=0.805$
At 12 months	3.67	1.4–9.62	0.01	$I^2=0.0\%$, $p=0.788$
At 24 months	2.51	0.93–6.75	0.07	$I^2=0.0\%$, $p=0.916$
At 48 months	2.55	0.95–6.8	0.06	$I^2=0.0\%$, $p=0.772$
Harris hip score (numerical value)				
At 12 months	0.95 ± 0.4	0.17–1.74	0.02	$I^2=63.5\%$, $p=0.098$
At 24 months	0.96 ± 0.4	0.06–1.86	0.04	$I^2=77.2\%$, $p=0.036$
Harris hip score (categorical value as excellent & good)				
At 6 months	0.30	0.12–0.72	0.008	$I^2=0.0\%$, $p=0.64$
At 12 months	0.44	0.20–0.97	0.04	$I^2=0.0\%$, $p=0.45$
Postoperative pain				
At 6 months	1.23	0.88–1.71	0.22	$I^2=0.0\%$, $p=0.522$
At 12 months	2.30	1.18–4.48	0.01	$I^2=0.0\%$, $p=0.038$
At 24 months	4.54	1.54–13.43	0.01	$I^2=0.0\%$, $p=0.506$
At 48 months	4.54	1.54–13.43	0.01	$I^2=0.0\%$, $p=0.506$
6 Min walking test (at 6–12 Months)	2.43 ± 2.82	– 3.1 to 7.9	0.39	$I^2=98.7\%$, $p=0.0$
EQ-5D index score (at 48 months)	0.49 ± 0.16	0.16–0.81	0.003	$I^2=0.0\%$, $p=0.32$
Range of motion at 12 months				
Flexion	2.58 ± 2.55	– 2.42 to 7.58	0.31	$I^2=98.5\%$, $p=0.0$
Adduction	2.27 ± 2.26	– 2.16 to 6.7	0.31	$I^2=98.2\%$, $p=0.0$
Abduction	3.76 ± 3.54	– 3.19 to 10.71	0.28	$I^2=98.7\%$, $p=0.0$
External rotation	2.71 ± 2.64	– 2.46 to 7.89	0.30	$I^2=98.5\%$, $p=0.0$
Deep infection				
At 12 months	0.6	0.19–1.95	0.40	$I^2=0.0\%$, $p=0.87$
At 24 months	0.73	0.27–2.03	0.55	$I^2=0.0\%$, $p=0.71$
At 48 months	0.65	0.12–3.61	0.62	$I^2=11.6\%$, $p=0.32$
Mortality rate				
At 6 months	0.95	0.58–1.55	0.83	$I^2=0.0\%$, $p=0.44$
At 12 months	0.84	0.59–1.2	0.34	$I^2=0.0\%$, $p=0.74$
At 24 months	0.86	0.52–1.43	0.57	$I^2=0.0\%$, $p=0.52$
At 48 months	0.92	0.56–1.52	0.76	$I^2=0.0\%$, $p=0.83$
Reoperation rate				
At 12 months	1.04	0.51–2.1	0.92	$I^2=0.0\%$, $p=0.53$
At 24 months	0.89	0.42–1.88	0.76	$I^2=0.0\%$, $p=0.46$
At 48 months	1.00	0.38–2.64	1.00	$I^2=35.13\%$, $p=0.18$
Dislocation rate				
At 6 months	0.94	0.29–2.98	0.91	$I^2=0.0\%$, $p=0.89$
At 12 months	1.25	0.58–2.66	0.55	$I^2=0.0\%$, $p=0.96$
At 24 months	1.64	0.66–4.04	0.28	$I^2=0.0\%$, $p=0.93$
At 48 months	1.72	0.61–4.83	0.30	$I^2=0.0\%$, $p=0.78$

Statistically significant *p* values are presented in bold numbers

at 12 and 24 months. Cornell et al. [28] found a statistically significant difference at 6 months, also in favor of the bipolar group. However, no significant difference was found in the study by Stoffel et al. [14] during a period of 12 months postoperative follow-up.

Postoperative pain

Patients in the bipolar group had significantly less risk for postoperative pain at 12, 24 and 48 months postoperatively, compared with the unipolar group (OR 2.30, 95% CI

Hip function (HHS)

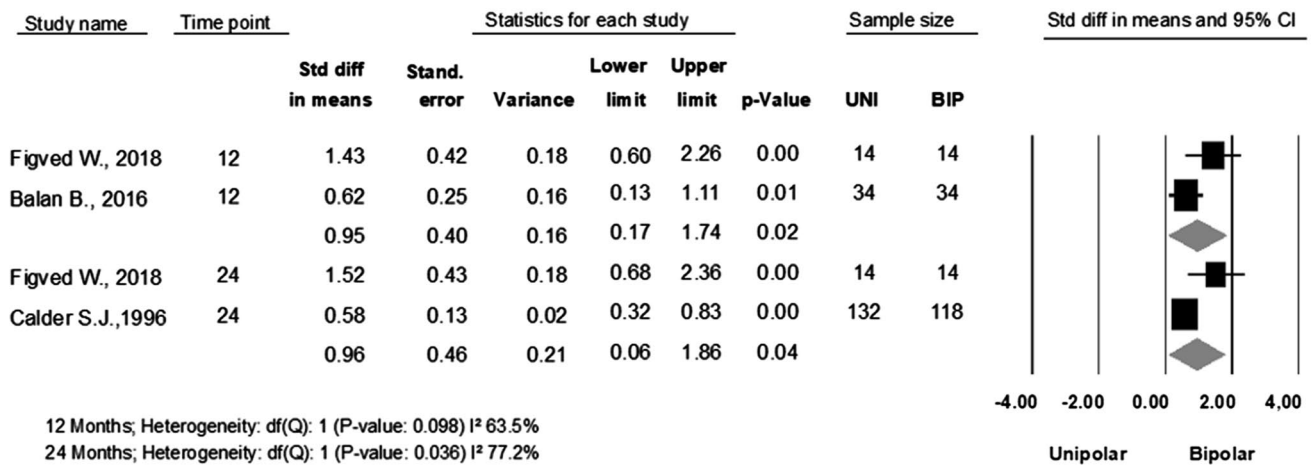


Fig. 3 The postoperative hip function assessed by the HHS (Harris Hip Score) provided as a numerical value

Excellent – Good Hip Function

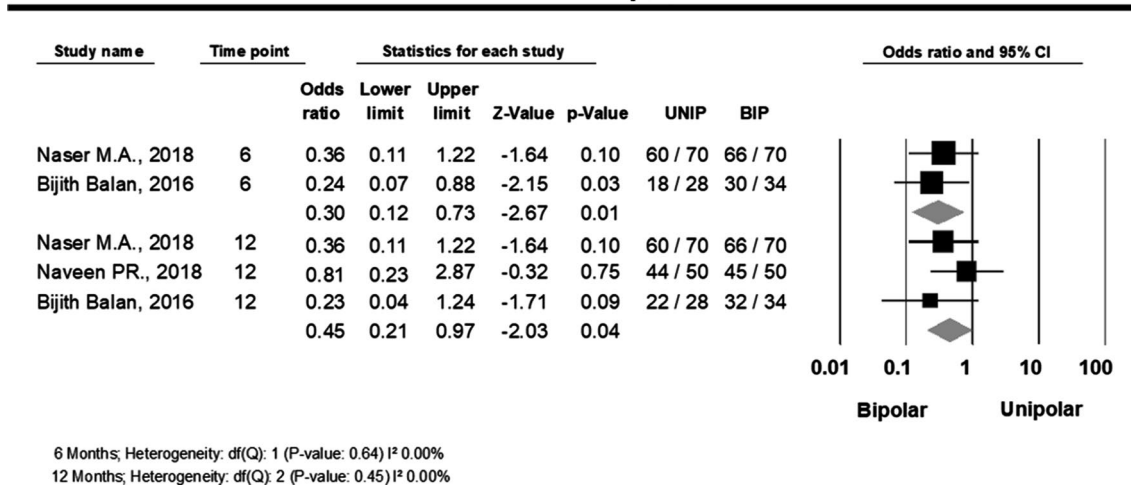


Fig. 4 The postoperative hip function assessed by the HHS (Harris Hip Score) provided as a stratified result using excellent/good/fair/poor as possible outcomes

1.18–4.48, $p=0.01$; I^2 0.0%, OR 4.54, 95% CI 1.54–13.43, $p=0.01$; I^2 0.0% and OR 4.54, 95% CI 1.54–13.43, $p=0.01$; I^2 0.0%) (Fig. 5, Table 2).

Postoperative ROM

No significant differences were found between the two groups regarding the postoperative ROM. Based on data available from two studies [11, 27], and at 12 months postoperatively, no significant differences were found regarding hip flexion (SMD 2.58 ± 2.55 , 95% CI – 2.42 to 7.58, $p=0.31$; I^2 98.58%), adduction (SMD 2.27 ± 2.26 , 95%

CI – 2.16 to 6.7, $p=0.31$; I^2 98.25%), abduction (SMD 3.76 ± 3.54 , 95% CI – 3.19 to 10.71, $p=0.28$; I^2 98.72%) and external rotation (SMD 2.71 ± 2.64 , 95% CI – 2.46 to 7.89, $p=0.30$; I^2 98.59%) (Fig. 6, Table 2).

Postoperative rates of deep infection, mortality, dislocation and reoperation rates

No significant difference was found between the two groups regarding these parameters at all time points (6, 12, 24 and 48 months) (Figs. 7, 8, 9 and 10, Table 2).

Postoperative Pain

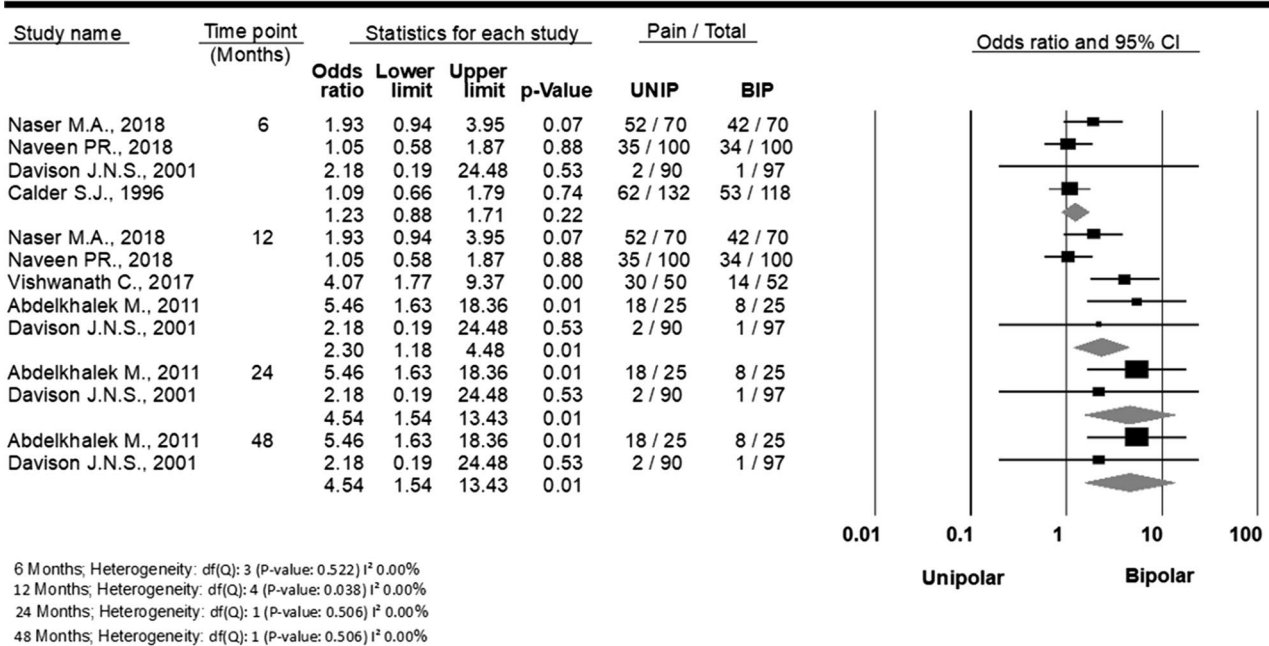


Fig. 5 The postoperative pain at 12, 24 and 48 months postoperatively

Range of motion

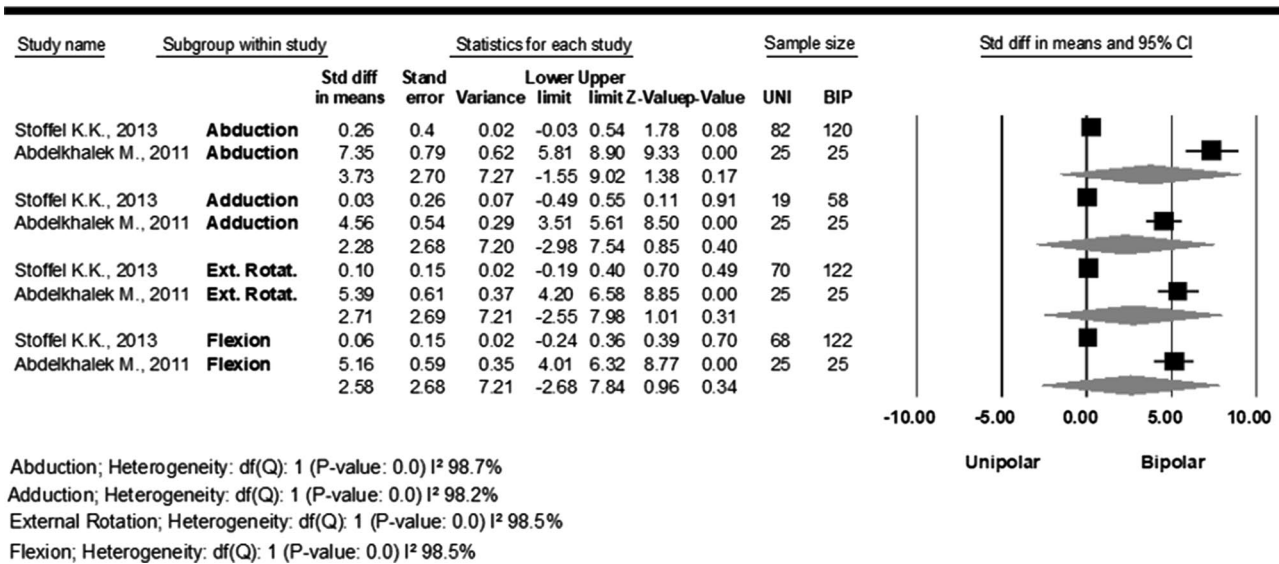


Fig. 6 The postoperative range of motion at 12-month follow-up

Postoperative QoL

A statistically significant difference favoring the bipolar group was found. Two studies [9, 11] evaluated the

EQ-5D index score at 48 months postoperatively. They both reported statistically significant difference favoring the bipolar group (SMD 0.49 (0.16), 95% CI 0.16–0.81, $p = 0.003$; I^2 0.0%).

Deep Infection

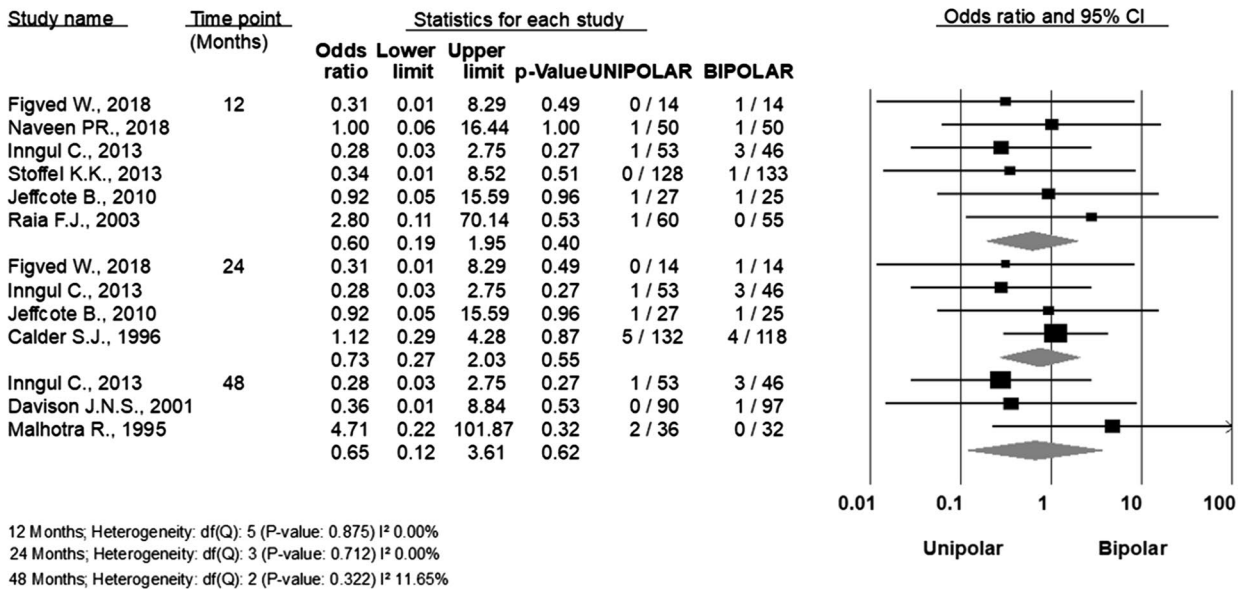


Fig. 7 The postoperative deep infection rates at all time points (12, 24 and 48 months)

Mortality Rate

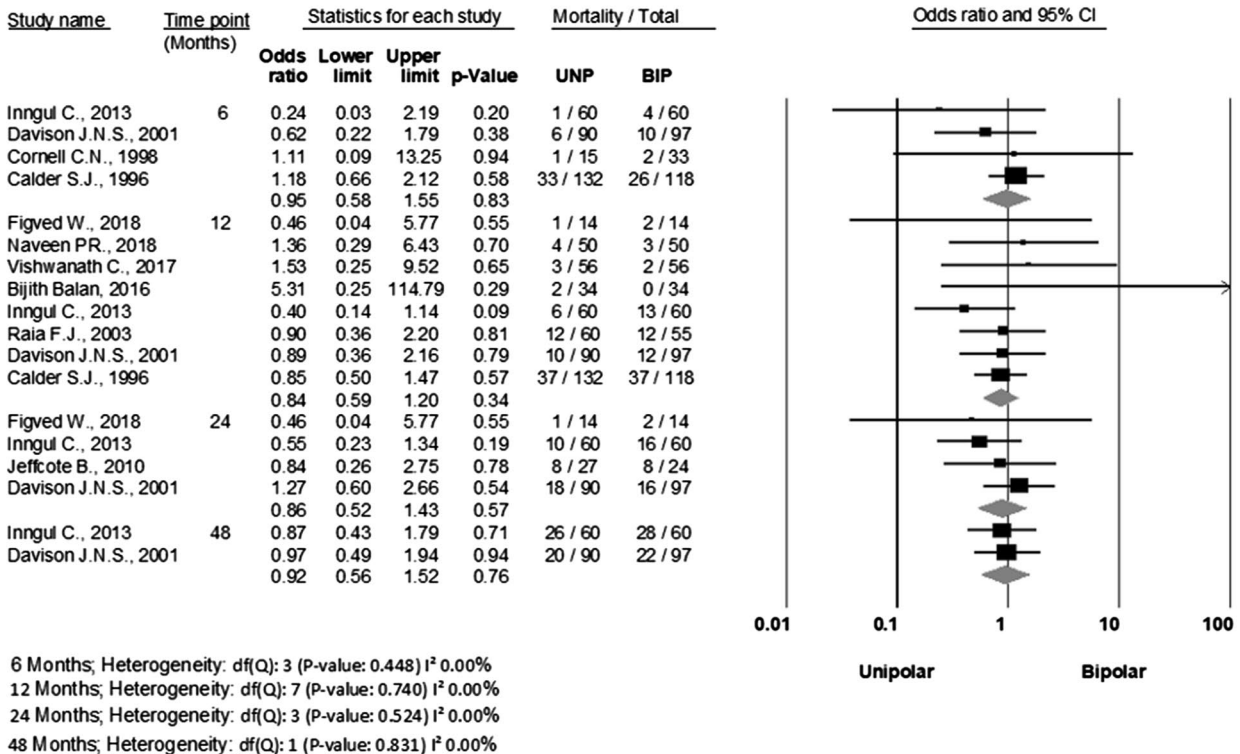


Fig. 8 The postoperative mortality rates at all time points (6, 12, 24 and 48 months)

Dislocation Rate

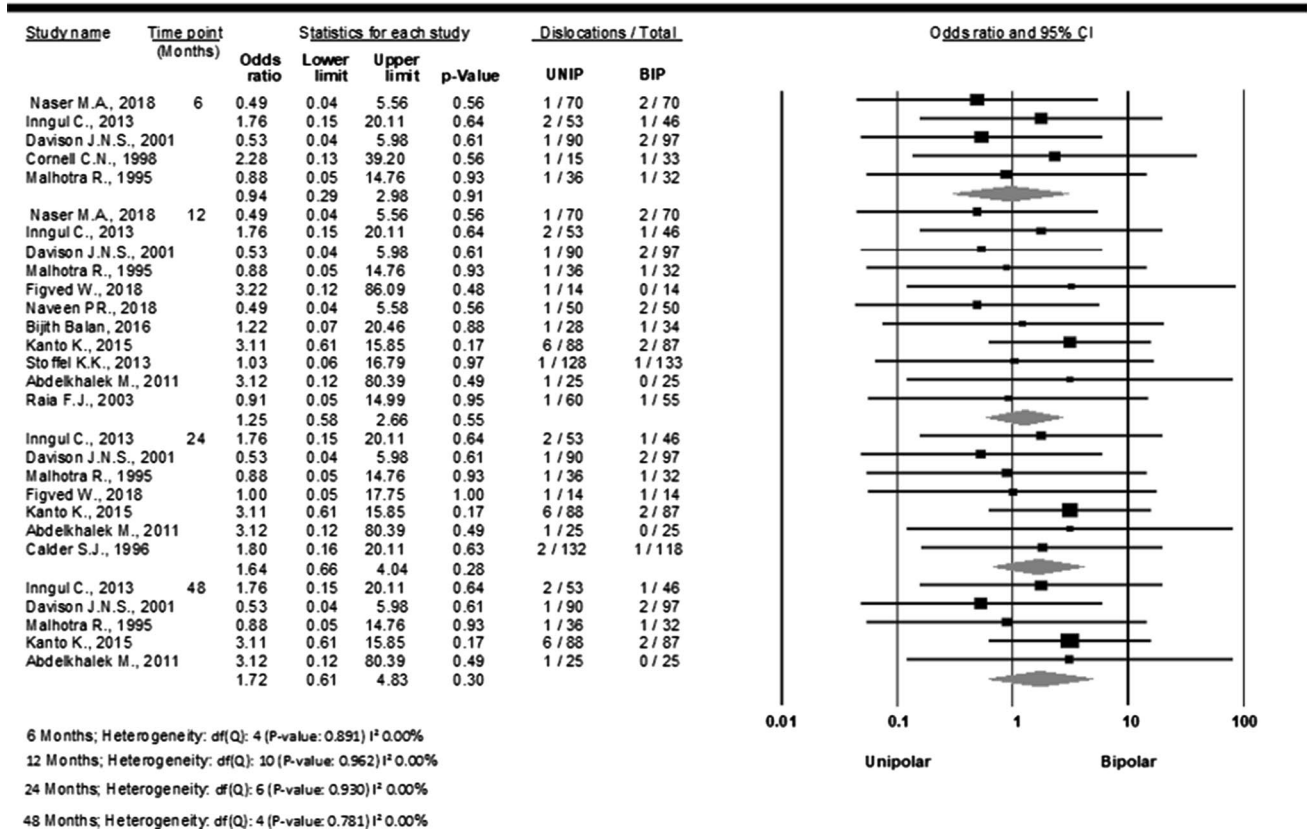


Fig. 9 The postoperative dislocation rates at all time points (6, 12, 24 and 48 months)

Sensitivity analysis

Sensitivity analysis was conducted by removal of each individual study; no difference was observed in the pooled results on none of the outcomes evaluated on our study.

Publication bias assessment

To assess the risk of publication bias, we used the funnel plot of the more frequent reported outcome of interest (reoperation). Visual inspection of the funnel plot showed a homogeneous and symmetric distribution of the referral points adjacent to the no-effect line (Fig. 11). Moreover, Egger’s test revealed no statistically significant asymmetry (Y-intercept – 0.67, 95% CI – 3.4 to 2.51, $p=0.64$).

Discussion

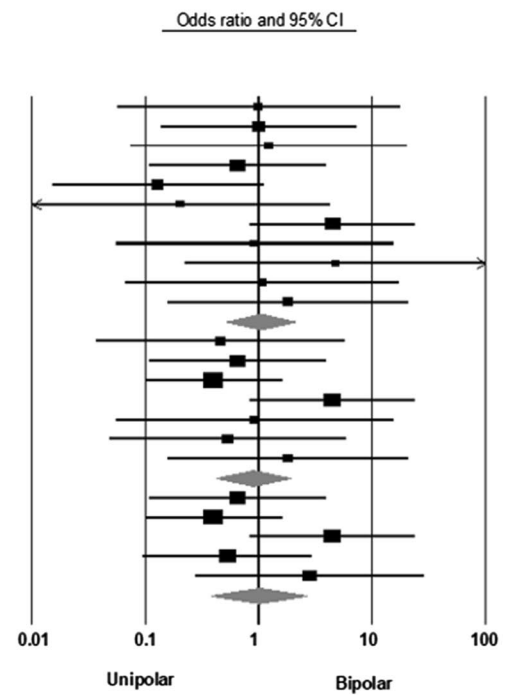
Hip hemiarthroplasty is considered to be the gold standard when treating elderly patients with displaced Femoral Neck Fractures [1, 3, 32, 33]. The purpose of this meta-analysis of randomized controlled trials study was to compare the

postoperative results of patients treated with bipolar or unipolar hemiarthroplasty at all available different time points, in order to determine if there are any significant differences in the erosion rates and postoperative functional outcomes [6, 8, 34–38]. We showed that patients with dFNFs treated with bipolar hemiarthroplasty have lower acetabular erosion rates at 6 and 12 months postoperatively, better hip function at 12 and 24 months postoperatively, better QoL and less pain, when compared with unipolar. No statistically significant differences could be established regarding deep infection, mortality, re-operation and dislocation rates.

This analysis has certain limitations. The relatively limited number and low level of evidence of the existing studies are important factors. Furthermore, the mean follow-up in some studies was quite short, there was heterogeneity regarding the definition and reporting of the acetabular erosion and differences existed concerning the patients’ age. The lack of data concerning the surgeons’ experience and the type of implants used (cemented vs. uncemented), the surgical approach, the patient’s comorbidities and the postoperative rehabilitation protocol may have also been factors affecting the quality of the analyzed data. Despite the fact that well-organized and executed meta-analyses may shed

Reoperation Rate

Study name	Time point (Months)	Statistics for each study					Odds ratio and 95% CI	
		Odds ratio	Lower limit	Upper limit	p-Value	UNIP	BIP	
Figved W., 2018	12	1.00	0.06	17.75	1.00	1 / 14	1 / 14	
Naveen PR., 2018		1.00	0.14	7.39	1.00	2 / 50	2 / 50	
Bijith Balan, 2016		1.22	0.07	20.47	0.89	1 / 28	1 / 34	
Kanto K., 2015		0.65	0.11	4.00	0.64	2 / 88	3 / 87	
Inngul C., 2013		0.13	0.01	1.11	0.06	1 / 53	6 / 46	
Stoffel KK., 2013		0.20	0.01	4.30	0.31	0 / 128	2 / 133	
Abdelkhalek M., 2011		4.47	0.83	24.19	0.08	7 / 25	2 / 25	
Jeffcote B., 2010		0.92	0.05	15.59	0.96	1 / 27	1 / 25	
Raia F.J., 2003		4.74	0.22	101.02	0.32	2 / 60	0 / 55	
Davison J.N.S., 2001		1.08	0.07	17.50	0.96	1 / 90	1 / 97	
Malhotra R., 1995		1.82	0.16	21.12	0.63	2 / 36	1 / 32	
Figved W., 2018		24	1.04	0.51	2.10	0.92		
Kanto K., 2015			0.46	0.04	5.77	0.55	1 / 14	2 / 14
Inngul C., 2013			0.65	0.11	4.00	0.64	2 / 88	3 / 87
Abdelkhalek M., 2011	4.47		0.83	24.19	0.08	7 / 25	2 / 25	
Jeffcote B., 2010	0.92		0.05	15.59	0.96	1 / 27	1 / 25	
Davison J.N.S., 2001	0.53		0.05	5.99	0.61	1 / 90	2 / 97	
Malhotra R., 1995	1.82		0.16	21.12	0.63	2 / 36	1 / 32	
Kanto K., 2015	48		0.89	0.42	1.88	0.76		
Inngul C., 2013			0.40	0.10	1.62	0.20	3 / 60	7 / 60
Abdelkhalek M., 2011			4.47	0.83	24.19	0.08	7 / 25	2 / 25
Davison J.N.S., 2001		0.53	0.09	2.96	0.47	2 / 90	4 / 97	
Malhotra R., 1995		2.82	0.28	28.55	0.38	3 / 36	1 / 32	
		1.00	0.38	2.64	1.00			



12 Months; Heterogeneity: $df(Q): 10$ (P-value: 0.531) I^2 0.00%
 24 Months; Heterogeneity: $df(Q): 6$ (P-value: 0.464) I^2 0.00%
 48 Months; Heterogeneity: $df(Q): 4$ (P-value: 0.187) I^2 35.13%

Fig. 10 The postoperative reoperation rates at all time points (12, 24 and 48 months)

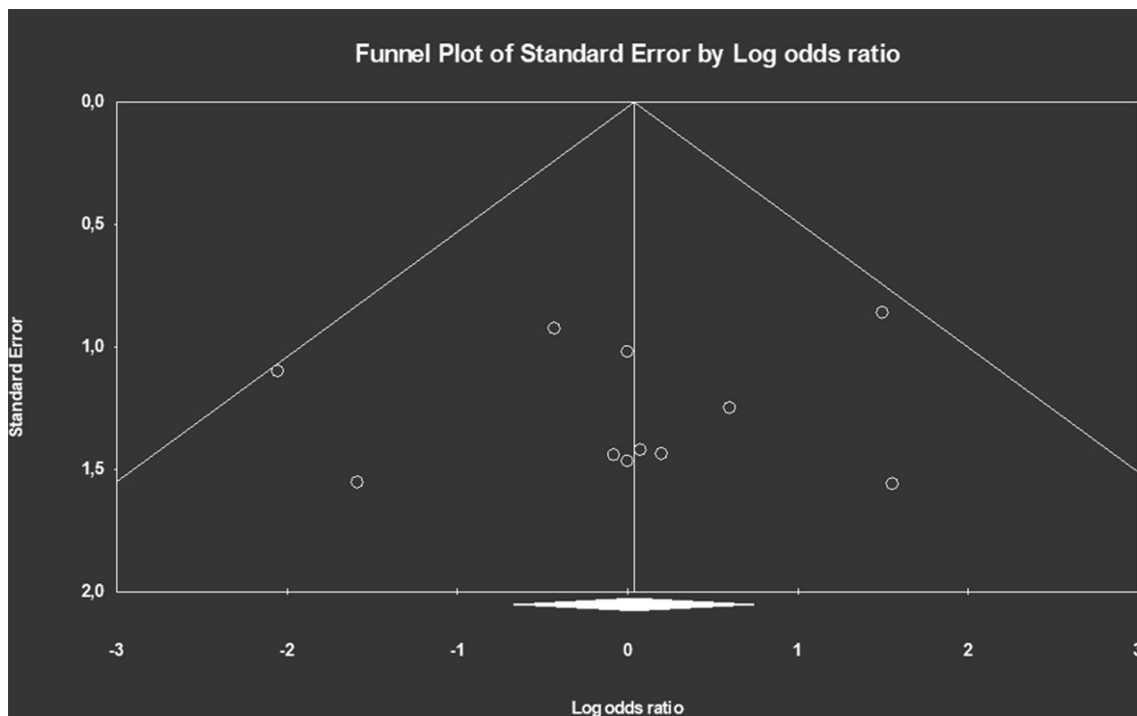


Fig. 11 Funnel plot of reoperation rate, the more frequent reported outcome of interest

additional light to difficult scientific problems, they still reflect the quality of included studies. Further to that, all available tools assessing the risk of bias do not warrant that all included studies are of high scientific standards.

The unipolar group had an increased risk to develop acetabular erosion at 6 and 12 months postoperatively, but not at 24 and 48 months. There are several previous meta-analyses of RCTs reporting on the acetabular erosion rate after a hip hemiarthroplasty [39–43]. Three of these report a statistically significant difference, favoring the group of patients treated with a bipolar hemiarthroplasty [40, 41, 43]. We evaluated data by using different postoperative time points based on the follow-up of each study. This finding may be attributed to the progressive loss of internal motion in the bipolar prosthesis which is observed over time. Several radiographic studies evaluating the joint motion of a bipolar hemiarthroplasty support this finding [44–46].

The postoperative hip function, as assessed by the HHS [9, 20, 21, 23, 26], showed a statistically significant difference favoring the bipolar group at 6, 12 and 24 months. One study [31] evaluating the HHS in 50 patients with a mean follow-up of 4.4 years, also reported statistically significant difference favoring the bipolar group ($p=0.004$). This finding is in contrast with previously published meta-analyses of RCTs [39–43]. This could be explained by the introduction of methodological errors in previous studies, since all these studies evaluated hip function by using combined data of both the HHS [13] and the modified HHS [17]. Moreover, two of these studies analyzed data acquired at different time points during the follow-up period [39, 40]. When evaluated by the six minutes' walk test, the postoperative hip function showed different results at different postoperative time points. Pooled results at 1 year showed no statistically significant difference, whereas individual studies by Jeffcote et al. [13] and Cornell et al. [28] reported statistically significant difference favoring the bipolar group at 3 and 6 months respectively. It must be noted though that the six minutes' walk test is an exercise test, used to evaluate aerobic capacity, performance and endurance [47]. The presence of concomitant pathologies may affect the physical performance in these elderly patients more than the hip function [48], even though proper randomization procedures may eliminate to a certain extent this potential bias.

No statistically significant differences were found in our study, concerning postoperative range of motion, deep infection rates, mortality, reoperation and dislocation rates. These results agree with those of most previously published studies [39–43], even though Zhang BF et al. [49] in a meta-analysis comparing internal fixation and (cemented and uncemented) hemiarthroplasty (unipolar and bipolar) and total arthroplasty reported lower reoperation incidence for unipolar cemented HA when compared with bipolar. The evaluation of the postoperative pain showed a statistically

significant difference, favoring the bipolar group, at 12, 24 and 48 months [20, 22, 25, 26, 31].

Another interesting finding of this study was that pooled results regarding the QoL evaluation score EQ-5D [14] at 48 months postoperatively showed a statistically significant difference favoring the bipolar group. This difference may be attributed to the decreased incidence of postoperative pain associated with the bipolar group. This result is in contrast with that reported by a recent meta-analysis of Beauchamp-Chalifour et al. [43]. However, the reader should take into consideration the fact that the strict exclusion criteria applied in our study contributed to more secure conclusions, at the expense of omitting lower-quality and/or non-relevant papers from our analysis.

Conclusion

This meta-analysis of randomized controlled trials showed that elderly patients with a displaced femoral neck fracture treated with bipolar hemiarthroplasty have lower acetabular erosion rates at 6 and 12 months postoperatively, together with better and less painful hip function and QoL, when compared with unipolar. No statistically significant difference could be established regarding deep infection, mortality, re-operation and dislocation rates.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00590-022-03320-0>.

Funding No funding was received to assist with the preparation of this manuscript.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Agar A, Utkan A (2021) The effect of anatomical reduction on functional outcomes in femoral neck fracture: a novel modified garden index. *Cureus* 13:e19863. <https://doi.org/10.7759/cureus.19863>
2. Katsanos S, Sioutis S, Reppas L, Mitsiokapa E, Tsatsaragkou A, Mastrokalos D, Koulalis D, Mavrogenis AF (2022) What do hip fracture patients die from? *Eur J Orthop Surg Traumatol Mar*. <https://doi.org/10.1007/s00590-022-03250-x>
3. Gausden EB, Cross WW 3rd, Mabry TM, Pagnano MW, Berry DJ, Abdel MP (2021) Total hip arthroplasty for femoral neck fracture: What are the contemporary reasons for failure? *J Arthroplasty* 36:S272–S276. <https://doi.org/10.1016/j.arth.2021.02.008>
4. Beauchamp-Chalifour P, Belzile EL, Racine LC, Nolet MP, Lemire S, Jean S, Pelet S (2020) The long-term postoperative trajectory of geriatric patients admitted for a hip fracture: a

- prospective observational cohort study. *Orthop Traumatol Surg Res* 106:621–625. <https://doi.org/10.1016/j.otsr.2019.11.017>
5. Kannan A, Kancherla R, McMahan S, Hawdon G, Soral A, Malhotra R (2012) Arthroplasty options in femoral-neck fracture: answers from the national registries. *Int Orthop* 36:1–8. <https://doi.org/10.1007/s00264-011-1354-z>
 6. Filippo M, Driessen A, Colarossi G, Quack V, Tingart M, Eschweiler J (2020) Bipolar versus monopolar hemiarthroplasty for displaced femur neck fractures: a meta-analysis study. *Eur J Orthop Surg Traumatol* 30:401–410. <https://doi.org/10.1007/s00590-019-02600-6>
 7. Kumar P, Rajnish RK, Neradi D, Kumar V, Agarwal S, Aggarwal S (2019) Hemiarthroplasty for neck of femur fractures: To cement or not? A systematic review of literature and meta-analysis. *Eur J Orthop Surg Traumatol* 29:731–746. <https://doi.org/10.1007/s00590-019-02364-z>
 8. Imam MA, Shehata M, Abdallah AR, Ahmed H, Kader N, Ernstbrunner L, Narvani AA, Kambouroglou G, Mcnamara I, Sallam AA (2019) Unipolar versus bipolar hemiarthroplasty for displaced femoral neck fractures: a pooled analysis of 30,250 participants data. *Injury* 50:1694–1708. <https://doi.org/10.1016/j.injury.2019.06.004>
 9. Figved W, Svenøy S, Röhrh SM, Dahl J, Nordsetten L, Frihagen F (2018) Higher cartilage wear in unipolar than bipolar hemiarthroplasties of the hip at 2 years: a randomized controlled radiostereometric study in 19 fit elderly patients with femoral neck fractures. *Acta Orthop* 89:503–508. <https://doi.org/10.1080/17453674.2018.1475899>
 10. Graulich T, Graeff P, Jaiman A, Nicolaidis S, Omar Pacha T, Örgel M, Macke C, Omar M, Krettek C, Lioudakis E (2021) Risk factors for dislocation after bipolar hemiarthroplasty: a retrospective case-control study of patients with CT data. *Eur J Orthop Surg Traumatol* 31:627–633. <https://doi.org/10.1007/s00590-020-02819-8>
 11. Inngul C, Hedbeck CJ, Blomfeldt R, Lapidus G, Ponzer S, Enocsson A (2013) Unipolar hemiarthroplasty versus bipolar hemiarthroplasty in patients with displaced femoral neck fractures. A four-year follow-up of a randomised controlled trial. *Int Orthop* 37:2457–2464. <https://doi.org/10.1007/s00264-013-2117-9>
 12. Ong BC, Maurer SG, Aharonoff GB, Zuckerman JD, Koval KJ (2002) Unipolar versus bipolar hemiarthroplasty: functional outcome after femoral neck fracture at a minimum of thirty-six months of follow-up. *J Orthop Trauma* 16:317–322. <https://doi.org/10.1097/00005131-200205000-00005>
 13. Jeffcote B, Li MG, Barnett-Moorcroft A, Wood D, Nivbrant B (2010) Roentgen stereophotogrammetric analysis and clinical assessment of unipolar versus bipolar hemiarthroplasty for subcapital femur fracture: a randomized prospective study. *ANZ J Surg* 80:242–246. <https://doi.org/10.1111/j.1445-2197.2009.05040.x>
 14. Stoffel KK, Nivbrant B, Headford J, Nicholls RL, Yates PJ (2013) Does a bipolar hemiprosthesis offer advantages for elderly patients with neck of femur fracture? A clinical trial with 261 patients. *ANZ J Surg* 83:249–254. <https://doi.org/10.1111/ans.12048>
 15. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D (2009) The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* 339:b2700. <https://doi.org/10.1136/bmj.b2700>
 16. Harris WH (1969) Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am* 51:737–755
 17. Vishwanathan K, Akbari K, Patel AJ (2018) Is the modified Harris hip score valid and responsive instrument for outcome assessment in the Indian population with pertrochanteric fractures? *J Orthop* 15:40–46. <https://doi.org/10.1016/j.jor.2017.12.001>
 18. Brooks R (1996) EuroQol: the current state of play. *Health Policy* 37:53–72. [https://doi.org/10.1016/0168-8510\(96\)00822-6](https://doi.org/10.1016/0168-8510(96)00822-6)
 19. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, Cates CJ, Cheng HY, Corbett MS, Eldridge SM, Emberson JR, Hernán MA, Hopewell S, Hróbjartsson A, Junqueira DR, Jüni P, Kirkham JJ, Lasserson T, Li T, McAleenan A, Reeves BC, Shepperd S, Shrier I, Stewart LA, Tilling K, White IR, Whiting PF, Higgins JPT (2019) RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 366:14898. <https://doi.org/10.1136/bmj.14898>
 20. Naser MA, Pathak R, Ahmad A (2018) Superiority of fixed stem bipolar prosthesis over Austin Moore prosthetic in fracture neck femur. *Int J Res Orthop* 4:577–581. <https://doi.org/10.18203/issn.2455-4510.IntJResOrthop20182415>
 21. Naveen PR, Kiran Kumar HG, Chaitanya PR, Badami RN (2018) Prospective randomised control study of bipolar versus unipolar prosthesis in the management of fracture neck of femur in elderly patients. *Int J Orthop Sci* 4:501–4. <https://doi.org/10.22271/ortho.2018.v4.i2h.77>
 22. Vishwanath C, Mummigatti SB (2017) Comparative study between austin moore prosthesis and bipolar prosthesis in fracture neck of femur. *Natl J Clin Orthop* 1:53–61
 23. Balan B, Shetty SK, Shetty AJ, Chandran R, Mathias LJ (2016) Displaced intra-capsular neck femur fractures in elderly: Austin Moore's prosthesis or cemented modular bipolar prosthesis. *IAIM* 3:287–296
 24. Malhotra R, Arya R, Bhan S (1995) Bipolar hemiarthroplasty in femoral neck fractures. *Arch Orthop Trauma Surg* 114:79–182. <https://doi.org/10.1007/BF00422830>
 25. Davison JN, Calder SJ, Anderson GH, Ward G, Jagger C, Harper WM, Gregg PJ (2001) Treatment for displaced intracapsular fracture of the proximal femur. A prospective, randomised trial in patients aged 65 to 79 years. *J Bone Joint Surg Br* 83:206–212. <https://doi.org/10.1302/0301-620x.83b2.11128>
 26. Calder SJ, Anderson GH, Jagger C, Harper WM, Gregg PJ (1996) Unipolar or bipolar prosthesis for displaced intracapsular hip fracture in octogenarians: a randomised prospective study. *J Bone Joint Surg* 78:391–394
 27. Raia FJ, Chapman CB, Herrera MF, Schweppe MW, Michelsen CB, Rosenwasser MP (2003) Unipolar or bipolar hemiarthroplasty for femoral neck fractures in the elderly? *Clin Orthop Relat Res*. <https://doi.org/10.1097/01.blo.0000081938>
 28. Cornell CN, Levine D, O'Doherty J, Lyden J (1998) Unipolar versus bipolar hemiarthroplasty for the treatment of femoral neck fractures in the elderly. *Clin Orthop Relat Res* 348:67–71
 29. Mishra AK, Chalise PK, Shah SB, Adhikari V, Singh RP (2013) Comparative study in surgical outcome of intracapsular fracture neck of femur in active elderly patients treated with hemiarthroplasty with Austin Moore's and bipolar prosthesis. *Nepal Med Coll J* 15:81–83
 30. Kanto K, Sihvonen R, Eskelinen A, Laitinen M (2014) Uni- and bipolar hemiarthroplasty with a modern cemented femoral component provides elderly patients with displaced femoral neck fractures with equal functional outcome and survivorship at medium-term follow-up. *Arch Orthop Trauma Surg* 134:1251–1259. <https://doi.org/10.1007/s00402-014-2053-1>
 31. Abdelkhalik M, Abdelwahab M, Ali AM (2011) Bipolar versus fixed-head hip arthroplasty for femoral neck fractures in elderly patients. *Strat Trauma Limb Reconstr* 6:1–6. <https://doi.org/10.1007/s11751-010-0100-1>
 32. Ng DZW, Lee KBL (2015) Unipolar versus bipolar hemiarthroplasty for displaced femoral neck fractures in the elderly: Is there a difference? *Ann Acad Med* 44:197–201

33. Investigators HEALTH, Bhandari M, Einhorn TA, Guyatt G, Schemitsch EH, Zura RD, Sprague S, Frihagen F, Guerra-Farfán E, Kleinlugtenbelt YV, Poolman RW, Rangan A, Bzovsky S, Heels-Ansdell D, Thabane L, Walter SD, Devereaux PJ (2019) Total hip arthroplasty or hemiarthroplasty for hip fracture. *N Engl J Med* 381:2199–2208. <https://doi.org/10.1056/NEJMoa190619>
34. Moerman S, Mathijssen NMC, Niesten DD, Riedijk R, Rijnberg WJ, Koëter S, Kremers van de Hei K, Tuinebreijer WE, Molenaar TL, Nelissen RGH, Vochteloo AJH (2017) More complications in uncemented compared to cemented hemiarthroplasty for displaced femoral neck fractures: a randomized controlled trial of 201 patients, with one year follow-up. *BMC Musculoskelet Disord* 18(1):300. <https://doi.org/10.1186/s12891-017-1526-0>
35. Taylor F, Wright M, Zhu M (2012) Hemiarthroplasty of the hip with and without cement: a randomized clinical trial. *J Bone Joint Surg Am* 94:577–583. <https://doi.org/10.2106/JBJS.K.00006>
36. Langslet E, Frihagen F, Opland V, Madsen JE, Nordsletten L, Figgved W (2014) Cemented versus uncemented hemiarthroplasty for displaced femoral neck fractures: 5-year followup of a randomized trial. *Clin Orthop Relat Res* 472:1291–1299. <https://doi.org/10.1007/s11999-013-3308-9>
37. Luo X, He S, Li Z, Huang D (2012) Systematic review of cemented versus uncemented hemiarthroplasty for displaced femoral neck fractures in older patients. *Arch Orthop Trauma Surg* 132:455–463. <https://doi.org/10.1007/s00402-011-1436-9>
38. Bhattacharyya T, Koval KJ (2009) Unipolar versus bipolar hemiarthroplasty for femoral neck fractures: Is there a difference? *J Orthop Trauma* 23:426–427
39. Liu Y, Tao X, Wang P, Zhang Z, Zhang W, Qi Q (2014) Meta-analysis of randomised controlled trials comparing unipolar with bipolar hemiarthroplasty for displaced femoral-neck fractures. *Int Orthop* 38:1691–1696. <https://doi.org/10.1007/s00264-014-2355-5>
40. Jia Z, Ding F, Wu Y, Li W, Li H, Wang D, He Q, Ruan D (2015) Unipolar versus bipolar hemiarthroplasty for displaced femoral neck fractures: a systematic review and meta-analysis of randomized controlled trials. *J Orthop Surg Res* 10:8. <https://doi.org/10.1186/s13018-015-0165-0>
41. Yang B, Lin X, Yin XM, Wen XZ (2015) Bipolar versus unipolar hemiarthroplasty for displaced femoral neck fractures in the elder patient: a systematic review and meta-analysis of randomized trials. *Eur J Orthop Surg Traumatol* 25:425–433. <https://doi.org/10.1007/s00590-014-1565-2>
42. Zhou Z, Yan F, Sha W, Wang L, Zhang X (2015) Unipolar versus bipolar hemiarthroplasty for displaced femoral neck fractures in elderly patients. *Orthopedics* 38:697–702. <https://doi.org/10.3928/01477447-20151016-08>
43. Beauchamp-Chalifour P, Pelet S, Belhumeur V, Angers-Goulet M, Bédard L, Belzile EL (2022) Should we use bipolar hemiarthroplasty in patients ≥ 70 years old with a femoral neck fracture? A review of literature and meta-analysis of randomized controlled trials. *J Arthroplasty* 37:601–608.e1. <https://doi.org/10.1016/j.arth.2021.12.004>
44. Chen SC, Badrinath K, Pell LH, Mitchell K (1989) The movements of the components of the Hastings bipolar prosthesis. A radiographic study in 65 patients. *J Bone Joint Surg* 71:186–188. <https://doi.org/10.1302/0301-620X.71B2.2925732>
45. Izumi H, Torisu T, Itonaga I, Masumi S (1995) Joint motion of bipolar femoral prostheses. *J Arthroplasty* 10:237–243. [https://doi.org/10.1016/s0883-5403\(05\)80133-0](https://doi.org/10.1016/s0883-5403(05)80133-0)
46. Jiang W, Xiao J, Chen B, Jia M, Zhang Y, Wang J, Shi Z (2020) Joint motion of bipolar hemiarthroplasty in routine hip functional movements: a dynamic motion study. *BMC Musculoskelet Disord* 21:731. <https://doi.org/10.1186/s12891-020-03749-6>
47. Bohannon RW, Crouch R (2017) Minimal clinically important difference for change in 6-minute walk test distance of adults with pathology: a systematic review. *J Eval Clin Pract* 23:377–381. <https://doi.org/10.1111/jep.12629>
48. Gkekas NK, Anagnostis P, Paraschou V, Stamiris D, Dellis S, Kenanidis E, Potoupnis M, Tsiridis E, Goulis DG (2021) The effect of vitamin D plus protein supplementation on sarcopenia: a systematic review and meta-analysis of randomized controlled trials. *Maturitas* 145:56–63. <https://doi.org/10.1016/j.maturitas.2021.01.002>
49. Zhang BF, Wang PF, Huang H, Cong YX, Wang H, Zhuang Y (2017) Interventions for treating displaced intracapsular femoral neck fractures in the elderly: a Bayesian network meta-analysis of randomized controlled trials. *Sci Rep* 7:13103. <https://doi.org/10.1038/s41598-017-13377-1>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.