

Does Arthroplasty Provide Better Outcomes Than Internal Fixation At Mid- and Long-term Followup? A Meta-analysis

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Abstract

Background Arthroplasty has been shown to be superior regarding low risk of reoperation and better function score to internal fixation for treatment of displaced femoral neck fractures at short-term followup. However, there are unanswered questions regarding the efficacy of arthroplasty in the longer term compared with internal fixation.

Questions/purposes We performed a meta-analysis comparing arthroplasty (hemiarthroplasty or THA) with internal fixation in patients with displaced femoral neck fractures with respect to (1) mortality, (2) reoperation, (3) functional recovery, and (4) complications, including only randomized trials with a minimum of 4 years followup.

Each author certifies that he or she, or a member of his or her immediate family, has no funding or commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

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Methods Computerized databases, including PubMed (MEDLINE), EMBASE, Cochrane Register of Controlled Trials databases, and Web of Science™ were searched for studies published from the inception date for each database to March 2014. Eleven randomized controlled trials that compared arthroplasty (either hemiarthroplasty or THA) with internal fixation for treatment of patients with a femoral neck fracture were included in our analysis. The quality of the trials was assessed according to the Cochrane Handbook and meta-analyses were conducted using RevMan 5.2 software from the Cochrane Collaboration. The heterogeneity among studies was evaluated by the I-squared index (I^2) and publication bias was assessed using forest plots.

Results There were no differences between the internal fixation and arthroplasty groups for patient mortality at mid-term (48.4% vs 46.8%) or long-term followup (83.2% vs 81.5%). Arthroplasty was associated with a lower risk of reoperation at mid-term (7.2% vs 39.8%; relative risk [RR] = 0.10; 95% CI, 0.06–0.07) and at long-term followup (14.3% vs 43.8%; RR = 0.10; 95% CI, 0.06–0.07). Arthroplasty was associated with better functional recovery at mid-term followup (standard mean difference [SMD] = 0.55; 95% CI, 0.02–1.09), whereas function at long-term followup (SMD = 0.14; 95% CI, –0.35 to 0.62) was not different between the arthroplasty and internal fixation groups. There were no significant differences in subsequent ipsilateral fractures (1.5% vs 1.2%; RR = 2.18; 95% CI, 0.32–14.67; $p = 0.42$) and deep infections (2.7% vs 2.9%; RR = 0.89; 95% CI, 0.40–2.01; $p = 0.78$) between patients treated with arthroplasty and internal fixation.

Conclusions Based on our results, we found that compared with internal fixation, arthroplasty may result in a lower rate of subsequent reoperation at mid- and long-term followup, and better mid-term functional recovery. Future

studies should investigate the mid- and long-term results of THAs compared with hemiarthroplasty.

Introduction

Hip fractures often are related to osteoporosis in older patients [20]. Every year, approximately 1.6 million people worldwide sustain hip fractures. A hip fracture in an older patient is a life-changing event and the risks of disability, increased dependence, and death are substantial [24]. Each year hip fractures are responsible for the loss of at least 2.35 million disability-adjusted life years and more than 5 million people worldwide experience disability from a hip fracture [7].

Established treatments for patients with femoral neck fractures—which account for almost 50% of all hip fractures [22]—differ greatly throughout the world. For young and active patients with good bone quality, treatment using reduction with internal fixation is common. In the elderly, surgical treatment options consist of internal fixation and arthroplasty [15]. Despite increasing data on femoral neck fractures [5], the optimal treatment for elderly patients with displaced femoral neck fractures is debatable.

A meta-analysis [8] assessing short-term followup concluded that arthroplasty was superior to internal fixation for treatment of patients with femoral neck fractures. However, it is unclear whether arthroplasty leads to better function, lower reoperation rate, and fewer complications in the long term [11]. Although there are some studies at longer term [20], including reporting results into the second decade [15], these series did not find differences between internal fixation and arthroplasty in terms of mortality. However, a meta-analysis might allow pooling of the data, which could increase the likelihood that smaller but potentially important clinical differences could be detected between treatments than is possible in individual trials.

We therefore sought to perform a meta-analysis comparing arthroplasty (hemiarthroplasty or THA) with internal fixation in patients with displaced femoral neck fractures with respect to (1) mortality, (2) reoperation, (3) functional recovery, and (4) complications, including only randomized trials with a minimum of 4 years followup.

Methods

Our study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [13].

We systematically searched PubMed (1966 to March 2014), EMBASE (1974 to March 2014), the Cochrane

Central Register of Controlled Trials (Issue 3, 2014), and Web of Science™ (1950 to March 2014) from inception to March 2014, without date, geographic, or language limitations. We used the following search terms: “arthroplasty”, “prosthetic replacement”, “internal fixation”, “femoral neck fractures”, and “randomised controlled trials”. Additionally, relevant articles, abstracts, and review articles were selected and reviewed, and the reference lists from these sources were searched for additional articles. We considered studies in which either THA or hemiarthroplasty were performed in the “arthroplasty” group. We did subanalyze to see whether there were differences between the THA and hemiarthroplasty subcohorts. All processes were performed by two reviewers (JJ, CHY) independently. The electronic database searches identified 301 citations. After evaluating the citations and reviewing articles and the bibliographies of the included studies, 11 studies [3–6, 10, 12, 14, 16–18, 21] involving 2299 patients were included for our meta-analysis (Fig. 1).

Two reviewers (XDY, YYX) independently assessed the studies and deemed them eligible if they met the following criteria: (1) randomized controlled trials (RCTs) comparing arthroplasty with internal fixation; (2) trials with at least 4 years of followup; (3) including patients with displaced fracture of the femoral neck (Garden Stage III or IV); and (4) reporting at least one of the following main clinical outcomes: reoperations for any cause, mortality, hip function score, and hip complications (dislocations, deep infections). All included studies were published in the English language and were performed in Europe. Sample sizes ranged from 100 to 455 cases with a mean followup of 9.9 years (range, 4–17 years). Based on the 11 studies that met all our criteria, 2299 patients were available for analysis. Of these, 1124 patients had an arthroplasty and 1175 patients had internal fixation (Table 1).

Primary outcomes of our meta-analysis were mortality rate and reoperation rate. Secondary outcomes included function scores and hip complications, including dislocation, periprosthetic fractures, and deep infection. Two authors (JJ and QL) independently extracted the following information from each study: year of publication, study design, number of patients, fracture classification, mean patient age, sex distribution, and mean length of followup. Inconsistencies in the extracted data were settled by consensus among all authors. As the followup time in each trial was different, the 11 trials were divided according to length of followup: mid-term results (4 to 6 years) and long-term results (10 to 17 years). Of the studies included in our analysis, none reported results between 6 and 10 years.

Two reviewers (CHY and XDY) independently assessed the methodology of the selected articles, according to the guidelines in the *Cochrane Handbook for Systematic Reviews of Interventions*, version 5.1 [9]. The domains we

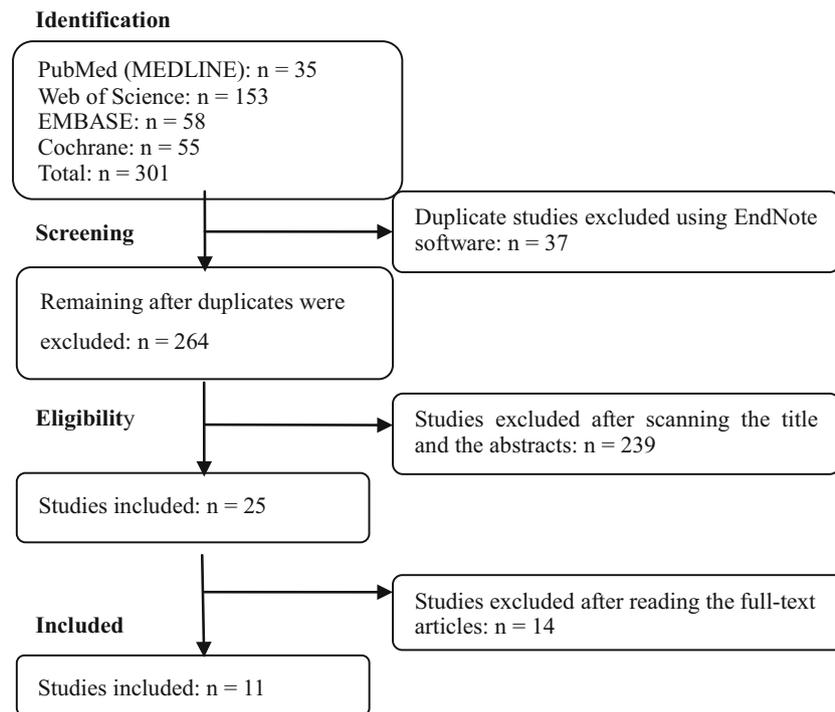


Fig. 1 A flow chart of the literature screening we used for this study is shown.

assessed were: random sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting, and other sources of bias. The reviewers resolved disagreements by discussion, and differences were reconciled by a third reviewer (YYX). All 11 studies were randomized; 10 of the studies had concealment of allocation, whereas only one study [14] did not. Three studies [3, 6, 14] used a blinded outcome assessor, whereas in the remaining eight studies, the outcome assessor was not blinded. Each study had specified entry criteria and defined outcome measures (Table 2).

All statistical analyses were performed using Review Manager (RevMan) software, version 5.2 (The Nordic Cochrane Centre, The Cochrane Collaboration, 2012; Copenhagen, Denmark). For dichotomized outcomes, such as patient mortality or reoperation, we calculated the relative risk (RR) and corresponding 95% CI using the number of events and total number of participants in each treatment arm. For continuous data hip function score (The Harris or Charnley hip scores), we calculated and pooled using standard mean difference (SMD). To assess heterogeneity, we used the I^2 statistic. In analyses in which heterogeneity was low ($I^2 < 50\%$), a fixed-effects model was used; otherwise, a random-effects model was used. A funnel plot based on the primary outcome was used to evaluate publication bias.

Results

We found no differences in patient mortality at mid-term (46.8% vs 48.4%; RR = 0.91; 95% CI, 0.76–1.10; $p = 0.62$) compared with long-term (81.5% vs 83.2%; RR = 0.85; 95% CI, 0.64–1.12; $p = 0.36$) between the two groups. There was no significant heterogeneity ($p = 0.62$; $I^2 = 0\%$) between studies, so we used a fixed-effect model for the meta-analysis of mortality. Data regarding patient mortality at mid-term and long-term followups were provided in nine studies [3, 5, 6, 12, 14, 16–18, 21] involving 1033 patients (Table 3). Subgroup analysis showed that there was no difference in comparison of either THA or hip arthroplasty with internal fixation at mid- and long-term followups (Table 4). The result for publication bias using the mortality rate revealed that there was publication bias among the included studies.

Arthroplasty was associated with a lower risk of subsequent reoperations at mid-term (7.2% vs 39.8%; RR = 0.10; 95% CI, 0.06–0.07; $p = 0.09$) and at long-term (14.3% vs 43.8%; RR = 0.22; 95% CI, 0.11–0.43; $p = 0.003$) compared with internal fixation. Substantial heterogeneity was observed ($p < 0.01$; $I^2 = 69\%$), so we used a random-effect model here. Eleven studies reported reoperation rates at mid- and long-term followups [3–6, 10, 12, 14, 16–18, 21] (Table 3). Subgroup analysis revealed

Table 1. Characteristics of included studies

Study	Country	Number of patients		Age of patients (years)	Intervention		Indication	Followup (years)
		Arthroplasty	Internal fixation		Arthroplasty	Internal fixation		
Blomfeldt et al. [3] 2005	Sweden	49	53	79.2/81.4	THA	2 cannulated screws	Displaced intracapsular fractures of hip, Garden Stages III/IV	4
Cao et al. [4] 2014	China	157	128	75.9/76.8	THA	3 hollow compression screws	Displaced femoral neck fractures	5
Chammout et al. [5] 2012	Sweden	43	57	78/79	THA	2 cannulated screws	Displaced femoral neck fractures	17
Davison et al. [6] 2001	UK	187	93	75/73	Hemiarthroplasty	AMBI compression hip screw and 2-hole plate	Displaced intracapsular fracture of the proximal femur	5
Johansson [10] 2014	Sweden	68	78	83.8/83.7	THA	2 parallel and percutaneously inserted screws	Displaced femoral neck fracture, Garden Stages III/IV	15
Leonardsson et al. [12] 2010	Sweden	192	217	81.6/81.5	THA, hemiarthroplasty	Hansson hook pins or Olmed screws	Displaced femoral neck fracture, Garden Stages III/IV	10
Mouzopoulos et al. [14] 2008	Greece	71	38	73.4/75.4	THA, hemiarthroplasty	Richards screw-plate	Displaced subcapital fracture, Garden Stages III/IV	4
Parker and Pryor [16] 2010	UK	229	226	82	Hemiarthroplasty	3 AO screws	Femoral neck fracture	15
Ravikumar and Marsh [17] 2000	UK	91	91	> 65	THA, hemiarthroplasty	Richards compression screw and plate	Displaced femoral neck fracture, Garden Stages III/IV	13
Rödén et al. [18] 2003	Sweden	47	53	81/81	Hemiarthroplasty	von Bahr screws	Displaced femoral neck fracture, Garden Stages III/IV	5
Støen et al. [21] 2014	Norway	110	112	> 80	Hemiarthroplasty	Two parallel cannulated screws	Femoral neck fracture, Garden Stages III/IV	6

Table 2. Risk of bias in included studies

Study	Randomization	Allocation concealment	Blinding	Incomplete outcome data	Selective reporting	Other bias
Blomfeldt et al. [3]	RCT	Sealed envelope	Yes	No	Unclear	Unclear
Cao et al. [4]	RCT	Sealed envelope	Unclear	No	Unclear	Unclear
Chammout et al. [5]	RCT	Sealed envelope	Unclear	No	Unclear	Unclear
Davison et al. [6]	RCT	Sealed envelope	Yes	No	Unclear	Unclear
Johansson [10]	RCT	Sealed envelope	Unclear	No	Unclear	Unclear
Leonardsson et al. [12]	RCT	Sealed envelope	Unclear	No	Unclear	Unclear
Mouzopoulos et al. [14]	RCT	No	Yes	No	Unclear	Unclear
Parker et al. [16]	RCT	Sealed envelope	Unclear	No	Unclear	Unclear
Ravikumar and Marsh [17]	RCT	Sealed envelope	Unclear	No	Unclear	Unclear
Rödén et al. [18]	RCT	Sealed envelope	Unclear	No	Unclear	Unclear
Støen et al. [21]	RCT	Sealed envelope	Unclear	No	Unclear	Unclear

RCT = randomized controlled trial.

Table 3. Outcomes of study meta-analysis

Patient outcome	Included studies (reference number)	Number of patients (n/N)		SMD [†] or RR (95% CI)	p value	Heterogeneity (I ² = %)
		Arthroplasty	Internal fixation			
Mortality						
Mid-term	[3, 5, 6, 12, 14, 16, 17, 21]	441/943	479/990	0.91 (0.76–1.10)	0.35	0
Long term	[5, 12, 16, 18]	560/687	615/739	0.85 (0.64–1.12)	0.25	8
Reoperation						
Mid-term	[3, 4, 6, 14, 16, 17, 21]	62/865	336/844	0.12 (0.07–0.19)	0.001	53
Long term	[5, 10, 12, 18]	69/483	234/534	0.22 (0.11–0.43)	0.001	75
Function score						
Mid-term	[3, 5, 14, 21]	149	146	0.55 [†] (0.02–1.09)	0.04	79
Long term	[5, 18]	202	203	0.14 [†] (–0.35 to 0.62)	0.59	76
Dislocation						
Mid-term	[12, 16]	11/421	2/443	3.28 (0.06–192.16)	0.57	79
Long term	[5, 10, 18]	51/291	1/317	25.86 (7.09–94.34)	0.001	0
Deep infection						
Mid-term	[4]	5/157	2/128	2.07 (0.40–10.86)	0.39	Not provided
Long term	[5, 12, 18]	11/415	13/456	0.89 (0.40–2.01)	0.78	0
Subsequent ipsilateral fractures						
Mid-term	[3, 10, 16]	7/470	6/496	1.67 (0.16–16.95)	0.66	60
Long term	[5]	2/43	0/57	6.93 (0.32–148.12)	0.22	Not provided

RR = relative risk; SMD[†] = standard mean difference; n = number of patients with clinical symptoms; N = total number of patients.

that there were fewer reoperations in patients treated by either THA or hemiarthroplasty than by internal fixation at mid-term followup (Table 4).

Function was higher at mid-term (SMD = 0.55; 95% CI, 0.02–1.09; $p = 0.04$) in patients treated with arthroplasty than in those treated with internal fixation, with no differences found at long-term followup (SMD = 0.14; 95% CI, –0.35 to 0.62; $p = 0.04$). There was significant heterogeneity ($p < 0.01$; $I^2 = 77%$) among studies, so we

used a random-effect model for this analysis. Five studies [3, 5, 14, 17, 21], with a total of 677 patients provided patient function outcomes at mid-term and long-term postoperatively. Subgroup analysis showed that function outcome was superior in patients treated with either THA or hemiarthroplasty than for patients treated by internal fixation (Table 4).

There were no differences in subsequent ipsilateral fractures (RR = 2.18; 95% CI, 0.32–14.67; $p = 0.42$) and

Table 4. Subgroup analysis of main outcomes

Outcomes	Included studies	Number of patients (n/N)		SMD [†] or RR (95% CI)	p value	Heterogeneity (I ² = %)
		Arthroplasty	Internal fixation			
Mortality at mid-term						
THA	[3, 5]	20/92	28/110	0.81 (0.4–1.56)	0.53	0
Hemiarthroplasty	[6, 16, 17, 21]	297/573	323/577	0.83 (0.65–1.06)	0.13	I0
Mortality at long term						
THA	[5]	60/86	90/114	0.60 (0.3–1.16)	0.13	I20
Hemiarthroplasty	[16]	206/229	199/226	1.22 (0.67–2.19)	0.52	Not provided
Reoperation at mid-term						
THA	[3, 4]	18/206	68/181	0.12 (0.03–0.55)	< 0.01	33
Hemiarthroplasty	[6, 16, 17, 21]	38/573	250/577	0.09 (0.06–0.13)	< 0.01	1
Reoperation at long term						
THA	[5, 10]	25/111	75/135	0.22 (0.13–0.40)	< 0.01	I0
Function score at mid-term						
THA	[3, 5]	69	78	0.21 [†] (–0.12 to 0.53)	0.21	0
Hemiarthroplasty	[21]	37	30	0.00 [†] (–0.48 to 0.48)	1.00	Not provided
Function score at long term						
THA	[5]	22	21	0.17 [†] (–0.43 to 0.77)	0.58	Not provided

RR = relative risk; SMD[†] = standard mean difference; n = number of patients with clinical symptoms; N = total number of patients.

deep infections (RR = 0.89; 95% CI, 0.40–2.01; $p = 0.78$) between patients treated with arthroplasty and internal fixation. Substantial heterogeneity was not observed ($p = 0.85$; $I^2 = 0\%$), so we used a fixed-effects model for the meta-analysis of complications. Six studies [3, 5, 10, 12, 16, 17] with a total of 1372 patients covered major complications.

Discussion

The best treatment for patients with displaced femoral neck fractures is debatable. Evidence from a meta-analysis [8] showed short-term results of arthroplasty to be superior to those of internal fixation. However, long-term results of arthroplasty compared with results of internal fixation remain controversial [3, 5, 6, 10, 12, 19, 21]. We therefore compared mid- and long-term results after arthroplasty or internal fixation in patients with femoral neck fractures. Eleven RCTs that reported outcomes with at least 4 years of followup were identified. The most important findings of our study were that arthroplasty was associated with a lower risk of subsequent reoperations at mid- and long-term followups. In terms of complications, there were no differences in frequency of infection between the groups, and some patients treated with arthroplasty had dislocations, and some with internal fixation had nonunions and osteonecrosis develop.

There were some limitations to our study. First, the methodologic quality of the included studies was not

optimal, although only RCTs were included in our analysis. For instance, only three studies [3, 6, 14] used blinding. The result of a funnel plot for mortality rate showed there was publication bias among studies; this might be because only English-language studies were included. Second, the type of arthroplasty (hemiarthroplasty or total arthroplasty, cemented or uncemented) and internal fixation methods (screws versus other) may have had an effect on the final treatment, although the subgroup analysis based on THA or hemiarthroplasty was conducted. Third, high mortality was found in the internal fixation group, therefore potential risk factors should be examined in the future studies. Finally, there was a paucity of data regarding time from injury to definitive treatment, which would be important in avoiding complications such as osteonecrosis in an open reduction and internal fixation or venous thromboembolism with an arthroplasty. Only one study [5] reported the delay in the group with open reduction and internal fixation, with two of 93 patients who had open reduction and internal fixation receiving delayed surgical treatment.

Regarding mortality, our meta-analysis showed that at mid- and long-term followups, the patient mortality rate did not differ between patients who had arthroplasty or internal fixation. Some studies [2, 12] with short-term followup showed that a statistically significant incremental trend in risk of death occurred after arthroplasty compared with the risk during short-term followup after internal fixation. However, long-term results [5, 10, 21] showed no difference in mortality rates between arthroplasty and internal fixation in patients treated for displaced femoral neck

fractures. In our meta-analysis, we found no difference in patient mortality between the two procedures at mid- and long-term followups.

Regarding reoperation, our meta-analysis revealed that arthroplasty decreased patient risk of reoperation compared with internal fixation at mid- and long-term followups. Internal fixation provides the possibility of retaining the native hip, but clinical failure resulting in reoperation occurs in approximately 1/3 of patients with displaced femoral neck fractures treated with internal fixation [23]. The percentages of patients undergoing reoperations at mid- and long-term followups in our meta-analysis were 6.5% (62/865) and 14.3% (69/483) in the arthroplasty group, and 39.8% (336/844) and 43.8% (234/534) in the internal fixation group, respectively, results which are similar to those of previous studies [5, 12, 17]. In a randomized trial with a followup of 13 years, Ravikumar and Marsh [17] found that arthroplasty reduced long-term risks, which likely is attributable to greater mortality in patients 65 years or older with femoral neck fractures.

Another important clinical outcome was function score. Our study showed that patients treated with arthroplasty had better function recovery than those treated with internal fixation at mid-term, whereas we found no difference in function between treatment groups at long-term followup. With less patient pain and low reoperation rates, arthroplasty was thought to be a more restorative and cost-effective procedure than internal fixation [8]. A previous short-term study [8] showed that function was superior for patients treated with arthroplasty than for patients treated with internal fixation; however, the long-term results of our meta-analysis revealed that arthroplasty provided similar functional outcomes compared with internal fixation.

In addition, arthroplasty often was associated with an assumed risk of long-term complications, such as periprosthetic fracture and aseptic loosening [21]. In our meta-analysis, we found that arthroplasty was associated with a greater risk of hip dislocation at long-term followup, which was consistent with results of previous studies [5, 10, 12, 17], whereas higher risk of nonunion and avascular osteonecrosis were found in the internal fixation group at mid- and long-term followups. More importantly, our study showed that there were no differences in deep infections and subsequent ipsilateral fractures between groups, which was different with meta-analysis of short-term results [25].

Subgroup analysis based on THA or hemiarthroplasty showed no differences with respect to mortality rate and function score between either THA or hemiarthroplasty compared with internal fixation, except for reoperation rate. The mid- to long-term results of THA compared with hemiarthroplasty rarely were reported. Avery et al. [1] reviewed the 7- to 10-year results of THA compared with hemiarthroplasty for fracture of the femoral neck and

reported lower mortality and a trend toward superior function in patients with THA. Future studies comparing THA with hemiarthroplasty at long-term followup are needed to confirm these results.

Our meta-analysis of 11 RCTs with 2299 patients suggests that treatment with arthroplasty results in lower risk of reoperation and better function outcomes than use of internal fixation at mid-term and long-term followups, despite higher dislocation rates associated with arthroplasty. Well-designed randomized clinical studies with long-term followups are needed to confirm our results. In addition, future studies should be designed to determine which type of arthroplasty (total or hemiarthroplasty, cemented or uncemented) is better.

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