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SURVEY

Total Hip Arthroplasty Versus Hemiarthroplasty for Displaced Femoral Neck Fractures

Meta-analysis of Randomized Trials

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Abstract

Background Most patients with displaced femoral neck fractures are treated by THA and hemiarthroplasty, but it remains uncertain which if either is associated with better function and lower risks of complications.

Questions/purposes We performed a meta-analysis of randomized controlled trials (RCTs) to determine whether THA was associated with lower rates of reoperations, mortality, complications, and better function compared with hemiarthroplasty.

Methods We searched the PubMed, Embase, Chinese Biomedicine Literature, and Cochrane Register of Controlled Trials databases and identified 12 RCTs (including a total of 1320 patients) for meta-analysis. Risk ratios (RRs) and weighted mean differences (WMDs) from each trial were pooled using random-effects or fixed-effects models depending on the heterogeneity of the included studies.

Results THA was associated with a lower risk of subsequent reoperations compared with hemiarthroplasty (RR = 0.53; 95% CI, 0.34–0.84). There was no difference in mortality between patients undergoing THA and hemiarthroplasty (RR = 0.81; 95% CI, 0.60–1.09). For complications, there was a higher risk of dislocation in patients undergoing THA (RR = 1.99; 95% CI, 1.26–3.15), but there were no differences in local infections (RR = 1.60; 95% CI, 0.74–3.46) and general complications (RR = 1.15; 95% CI, 0.91–1.45). Patients with THA had higher Harris hip scores at 1 year (WMD = 3.81; 95% CI, 0.87–6.74) and at 3 or 4 years (WMD = 10.07; 95% CI, 6.92–13.21).

Conclusions Despite more dislocations, THA can benefit patients with displaced femoral neck fractures with a lower reoperation rate and higher functional scores.

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Introduction

Hip fracture is an international public health problem, and there are approximately 1.5 million hip fractures worldwide per year [40]. In 2050, there will be an estimated 3.9 million fractures worldwide, with more than 700,000 in the United States [40]. Hip fractures in older patients are associated with impaired mobility, excess morbidity and mortality, and obvious loss of independence [6, 14]. Thus, hip fractures remain a public health concern, especially with the aging population and with the high incidence of osteoporosis [14, 40].

A displaced femoral neck fracture is one of the most common hip fractures and these unstable fractures of the femoral neck generally need surgical intervention [4]. The goals of surgical treatment are immediate pain relief, rapid mobilization, accelerated rehabilitation, and a low risk of surgical complications or subsequent revision [26, 32]. Established surgical options for displaced femoral neck fracture mainly include internal fixation, hemiarthroplasty, and THA [4]. For decades, the optimal treatment choice has been debated, and whether THA is better than hemiarthroplasty for displaced femoral neck fractures is still uncertain [29, 30, 37, 38]. Many RCTs have evaluated the benefits of THA compared with hemiarthroplasty, but there is obvious inconsistency of effects across those studies [2, 3, 5, 11, 16, 22, 23, 27, 28, 34, 36, 39]. Meta-analysis has been recognized as an important tool to more precisely define the effect of clinical interventions and two systematic reviews have been published to compare the benefits of THA compared with hemiarthroplasty [15, 20]. A recent meta-analysis suggested THA was associated with lower reoperation rates compared with hemiarthroplasty for displaced femoral neck fractures [20]. However, this meta-analysis covered only seven eligible RCTs with a total of 769 patients. Furthermore, five new RCTs have been published since 2008 [9, 24, 25, 33, 41]. Therefore, to provide the most comprehensive assessment of THA and hemiarthroplasty for displaced femoral neck fractures, we performed an updated meta-analysis of all available RCTs.

We determined whether THA was associated with lower rates of reoperations, mortality, and complications and better function compared with hemiarthroplasty.

Search Strategy and Criteria

We searched the PubMed, Embase, Chinese Biomedicine Literature, and Cochrane Register of Controlled Trials databases for studies published between January 1980 and June 2011 with the search terms: ("total hip arthroplasty" or "total hip replacement" or "THA") and ("hemiarthroplasty" or "unipolar" or "bipolar" or "femoral head replacement"). No language restriction was applied. The reference lists of identified studies and key review articles also were searched. The inclusion criteria for this meta-analysis were RCTs comparing THA with hemiarthroplasty for displaced femoral neck fractures and reporting at least one of the following main clinical outcomes: reoperations for any cause, 1-year mortality, hip function (Harris hip score), local infections, general perioperative complications, and dislocations. We excluded case series investigating either THA or hemiarthroplasty for treating displaced femoral neck fractures.

We identified 167 articles through database searching plus two additional articles through other sources (Fig. 1). There were 105 articles after removing duplicates. We excluded 85 of these articles, leaving 20 potentially relevant studies [2, 3, 5, 9, 11, 15, 16, 21–25, 27–29, 33, 34, 36, 39, 41]. We then excluded eight more articles (three review articles [15, 21, 29] and five duplicate articles [3, 5, 23, 27, 39]), leaving 12 RCTs meeting our selection criteria

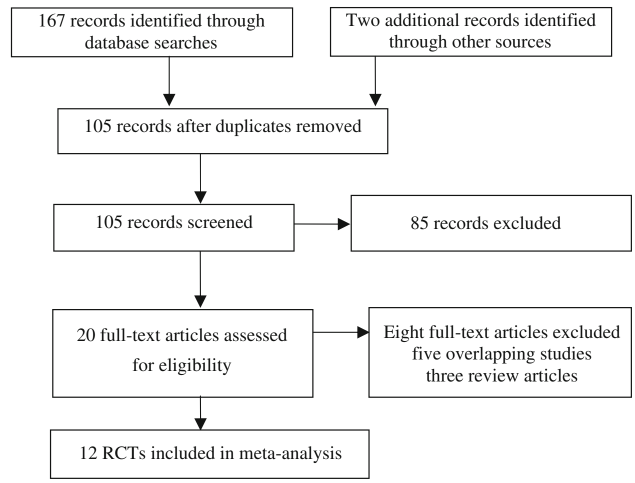

Fig. 1 A flowchart shows the selection of studies for inclusion in the meta-analysis.

and involving a total of 1320 patients (624 in the THA group and 696 in the hemiarthroplasty group) [2, 9, 11, 16, 22, 24, 25, 27, 28, 32, 36, 41] (Table 1).

Two of us (LY, JC) assessed the quality of the included RCTs using the scoring system of Jadad et al. [21], which evaluated studies based on randomization, blinding, and a description of withdrawals and dropouts (Table 1). Interobserver variability of assessing quality or inconsistencies were settled by consensus among all three authors. Among these studies, nine RCTs were high-quality studies (scoring 3 points or more), whereas the other three studies were low-quality studies (scoring 1 or 2 points). The Cochrane Risk of Bias Tool was used to assess the risk of bias in the included studies [17]. (Supplemental Table 1; supplemental materials are available with the online version of CORR).

From the full manuscripts, we extracted the following information from each study: year of publication, study design, number of patients, fracture classification, mean patient age, sex distribution, mean length of followup, type of prosthesis, and use of bone cement. To assess efficacy of treatment, we recorded reoperations for any cause, 1-year mortality, and hip function (Harris hip score). To assess complications associated with treatment, we recorded local infections, general perioperative complications (including pneumonia, urinary tract infections, thromboembolic events, and cardiovascular events), and dislocations. Inconsistencies in the extracted data were settled by consensus among all authors.

RRs and WMDs from each trial were pooled using random-effects or fixed-effects models depending on the heterogeneity of the included studies. As RRs were estimated to assess the advantage conferred by THA, an RR less than 1 was taken to indicate THA was superior to hemiarthroplasty. We used random-effects and fixed-effects

Table 1. Key characteristics and quality of studies included in the meta-analysis.

Study	Indication	Followup (months)	THA	Hemiarthroplasty	Main outcomes
Dorr et al. [11] 1986	Displaced femoral neck fractures Garden III/IV	24	39 cemented THAs	51 cemented or uncemented hemiarthroplasties	Reoperations, mortality, dislocations, local infections, mortality
Ravikumar and Marsh [36] 2000	Displaced femoral neck fractures Garden III/IV	156	91 cemented THAs	81 unipolar and uncemented hemiarthroplasties	Reoperations, mortality, dislocations, local infections
Keating et al. [22] 2005	Displaced femoral neck fractures	24	69 cemented THAs	111 bipolar and cemented hemiarthroplasties	Reoperations, mortality, dislocations, local infections, general complications
Avery et al. [2] 2011	Displaced femoral neck fractures	108	40 cemented THAs	41 cemented and bipolar hemiarthroplasties	Reoperations, mortality, dislocations, local infections, general complications
Hedbeck et al. [16] 2011	Displaced femoral neck fractures	48	60 cemented THAs	60 bipolar and cemented hemiarthroplasties	Reoperations, mortality, dislocations, local infections, general complications, function (Harris hip score)
Macaulay et al. [28] 2008	Displaced femoral neck fractures Garden III/IV	24	17 cemented or uncemented THAs	23 hemiarthroplasties	Reoperations, mortality, dislocations, local infections, general complications, function (Harris hip score)
Mouzopoulos et al. [33] 2008	Displaced femoral neck fractures Garden III/IV	48	43 cemented THAs	43 bipolar hemiarthroplasties	Reoperations, mortality, function (Harris hip score)
Deng et al. [9] 2009	Displaced femoral neck fractures Garden III/IV	36	28 cemented or uncemented THAs	28 cemented or uncemented hemiarthroplasties	Reoperations, dislocations, local infections, general complications, function (Harris hip score)
van den Bekerom et al. [41] (2010)	Displaced femoral neck fractures	60	115 cemented THAs	137 cemented hemiarthroplasties	Reoperations, mortality, dislocations, general complications
Lai [24] (2010)	Displaced femoral neck fractures Garden III/IV	34	20 uncemented THAs	22 uncemented hemiarthroplasties	Reoperations, dislocations, local infections, general complications
Li et al. [25] (2011)	Displaced femoral neck fractures	60	55 cemented or uncemented THAs	52 hemiarthroplasties	Dislocations, general complications, function (Harris hip score)
Pang [34] (2011)	Displaced femoral neck fractures	40	47 cemented or uncemented THAs	47 bipolar and cemented hemiarthroplasties	Dislocations, general complications, function (Harris hip score)

models to analyze dichotomous data. The random-effects model was conducted using the method of DerSimonian and Laird [10], and the fixed-effects model was conducted using the method of Mantel and Haenszel [31]. To assess the between-study heterogeneity more precisely, we performed heterogeneity testing by calculating the chi-square-based Q statistic test for heterogeneity and the I^2 statistic to quantify the proportion of the total variation attributable to heterogeneity [8, 18]. Heterogeneity was considered significant when the $P_{Q\ statistic}$ was less than 0.10, and the random-effects model was used to pool the relative data; otherwise, the fixed-effects model was used to pool the relative data. To validate the credibility of pooled results in this meta-analysis, we performed sensitivity analysis by sequential omission of individual studies. To better investigate possible sources of heterogeneity that might influence the results, meta-regression analysis also was used in this meta-analysis. Ten studies provided data for reoperations [2, 9, 11, 16, 22, 24, 28, 33, 36, 41]. There was no heterogeneity between trials ($I^2 = 17\%$; $p = 0.29$); therefore, the fixed-effects model was used to pool the relative data (Table 2). Nine studies provided data for mortality [2, 11, 16, 22, 25, 28, 33, 36, 41]. We observed no heterogeneity between trials ($I^2 = 0\%$; $p = 0.94$) and therefore used the fixed-effects model to pool the relative data (Table 2). There were six individual studies (including five studies at 1 year [9, 16, 25, 28, 33] and five studies at 3 or 4 years [9, 16, 25, 33, 34]) providing data for hip function as assessed by the Harris hip score. We found heterogeneity between trials (both $p < 0.01$), and the random-effects model was used to pool the relative data (Table 2). Eight studies provided data for local infections [2, 9, 11, 16, 22, 24, 28, 36]. There was no heterogeneity between these trials ($I^2 = 0\%$; $p = 0.79$); therefore, the fixed-effects model was used to pool the relative data (Table 2). Nine studies provided data for general complications [2, 9, 16, 22, 24, 25, 28, 34, 41]. We found no heterogeneity between trials ($I^2 = 24\%$; $p = 0.23$) and therefore used the fixed-effects model to pool the relative data (Table 2). Eleven studies provided data for dislocation [2, 9, 11, 16, 22, 24, 25, 28, 34, 36, 41]. Again, there was no heterogeneity between trials ($I^2 = 5\%$; $p = 0.39$), therefore we used the fixed-effects model to pool the relative data (Table 2).

We performed funnel plots, in which the standard error of log [RR] of each study was plotted against its log [RR], and Egger's linear regression test [12] to assess the publication bias. We first visually evaluated the symmetry of the funnel plots and did not find obvious evidence of asymmetry. In addition, all the p values of the Egger's tests were greater than 0.05, providing no statistical evidence of asymmetry of the funnel plots (Fig. 2). These results suggested publication bias was not evident in this meta-analysis.

Statistical analyses were performed using Review Manager (Version 5.0.2) (Cochrane Information Management System, http://ims.cochrane.org/revman) and STATA® (Version 12.0) (StataCorp LP, College Station, TX, USA) software programs. All p values were two-sided.

Results

THA was associated with a lower risk (4.6%) of subsequent reoperations compared with hemiarthroplasty (8.6%) (RR = 0.53; 95% CI, 0.34–0.84; $p = 0.006$) (Fig. 3A). Sensitivity analysis by sequential omission of individual studies showed no change in significance.

We found no difference (RR = 0.81; 95% CI, 0.60–1.09; $p = 0.17$) in mortality between patients undergoing THA (11.6%) and hemiarthroplasty (13.9%) (Fig. 3B). Sensitivity analysis showed the significance changed by omission of one study [41], which indicated the credibility of these pooled results was unstable and needs additional study.

Table 2. Summary of RRs and WMDs with 95% CIs in the meta-analysis.

Analysis item	Number of studies included	RR/WMD (95% CI)	p value	Heterogeneity		Model
				I^2 (%)	p value	
Efficacy						
Reoperation rates	10	0.53 (0.34, 0.84)	0.006	17	0.29	Fixed-effects
Mortality	9	0.81 (0.60, 1.09)	0.17	0	0.94	Fixed-effects
Harris hip scores at 1 year	5	3.81 (0.87, 6.74)	0.03	73	0.005	Random-effects
Harris hip scores at 3 or 4 years	5	10.07 (6.92, 13.21)	< 0.001	85	< 0.001	Random-effects
Complications						
Dislocations	11	1.99 (1.26, 3.15)	0.003	5	0.39	Fixed-effects
Local infections	8	1.60 (0.74, 3.46)	0.23	0	0.79	Fixed-effects
General complications	9	1.15 (0.91, 1.45)	0.25	0.23	0.23	Fixed-effects

RR = risk ratio; WMD = weighted mean difference.

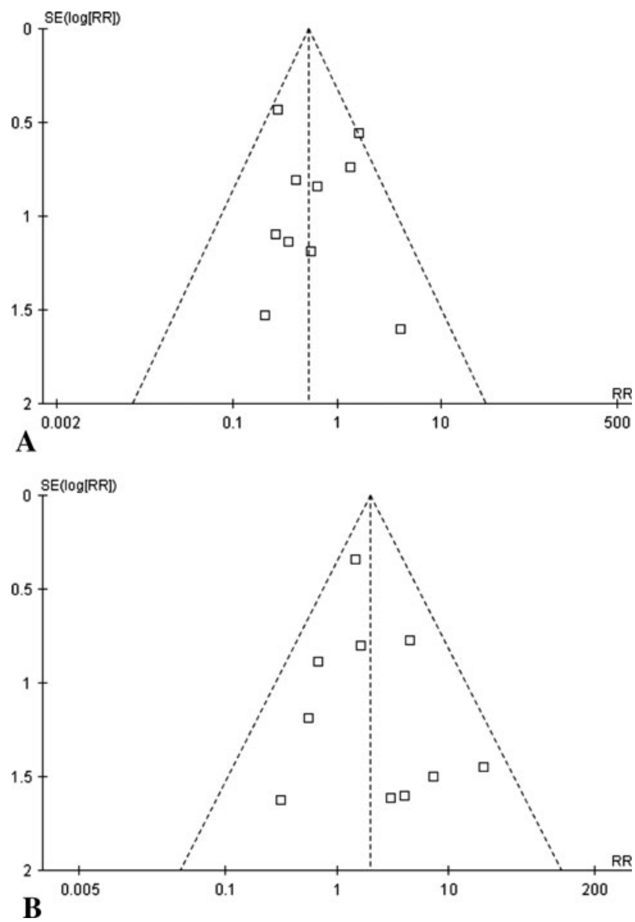

Fig. 2A–B The funnel plots assess publication bias of the meta-analysis comparing THA with hemiarthroplasty for displaced intracapsular hip fractures for (**A**) reoperations ($T_{Egger's\ test} = -0.62$; 95% CI, -1.41 to 2.45; $P_{Egger's\ test} = 0.55 > 0.05$) and (**B**) mortality ($T_{Egger's\ test} = -0.60$; 95% CI, -1.12 to 0.67; $P_{Egger's\ test} = 0.57 > 0.05$). SE = standard error.

The mean Harris hip scores at 1 year were higher after THA (WMD = 3.81; 95% CI, 0.87–6.74; p = 0.03), as were the mean Harris hip scores at 3 or 4 years (WMD = 10.07; 95% CI, 6.92–13.21; p < 0.001) (Fig. 3C). Sensitivity analysis by sequential omission of individual studies showed no change in significance. For the meta-analysis of hip function, we found heterogeneity between the trials; univariate analysis of meta-regression suggested the status of cemented or uncemented and surgery indications were important sources of between-study heterogeneity

We found no difference (RR = 1.60; 95% CI, 0.74–3.36; p = 0.23) in postoperative infections between patients undergoing THA (3.8%) and hemiarthroplasty (2.4%) (Fig. 4A). Sensitivity analysis by sequential omission of individual studies showed no change in significance. As with infections, we observed no difference (RR = 1.15; 95% CI, 0.91–1.45; p = 0.25) in general complications between patients undergoing THA (21.7%) and hemiarthroplasty (19.4%) (Fig. 4B). Sensitivity analysis by sequential omission of individual studies showed no change in significance. We found a higher risk of dislocation in patients undergoing THA (7.6%) (RR = 1.99; 95% CI, 1.26–3.15; p = 0.003) (Fig. 4C) compared with hemiarthroplasty (3.5%). Sensitivity analysis by sequential omission of individual studies showed no change in significance.

Discussion

Established surgical options for displaced femoral neck fractures mainly include internal fixation, hemiarthroplasty, and THA, but the optimal treatment choice continues to be debated and it is still uncertain whether THA is better than hemiarthroplasty for displaced femoral neck fractures [29, 30, 37, 38]. The latest meta-analysis showed THA might lead to a lower reoperation rate and better function compared with hemiarthroplasty for displaced femoral neck fractures [20]. However, the data available in that meta-analysis did not allow for definitive conclusions regarding the identified treatment effects, owing to varying interactions between subgroups and concerns regarding the random allocation of patients [20]. In addition, that meta-analysis covered only seven eligible RCTs with a total of 769 patients. Furthermore, five new RCTs have been published since 2008 [9, 24, 25, 33, 41]. Therefore, to provide the most comprehensive assessment of THA and hemiarthroplasty for displaced femoral neck fractures, we performed an updated meta-analysis to determine whether THA was associated with lower rates of reoperations, mortality, and complications and better function compared with hemiarthroplasty.

Some possible limitations to this meta-analysis should be acknowledged. First, the eligibility criteria for inclusion of patients with displaced femoral neck fractures differed for each study, which might influence the obvious consistency of effects across the included studies and cause between-study heterogeneity. Although the heterogeneity analyses did not find obvious between-study heterogeneity in this meta-analysis, the various eligibility criteria should be noted. In addition, to ensure uniformity in defining patient characteristics for displaced femoral neck fractures and clinical efficacy measures, a meta-analysis of individual patient data is needed [7]. Second, the clinical outcomes of cemented and uncemented hemiarthroplasties or THA differed [1, 19], and a previous Cochrane review suggested there was good evidence that cementing the prostheses in place would reduce postoperative pain and lead to better mobility [35], however, we did not perform subgroup analyses according to cemented or uncemented status owing to the limited studies reported in the original

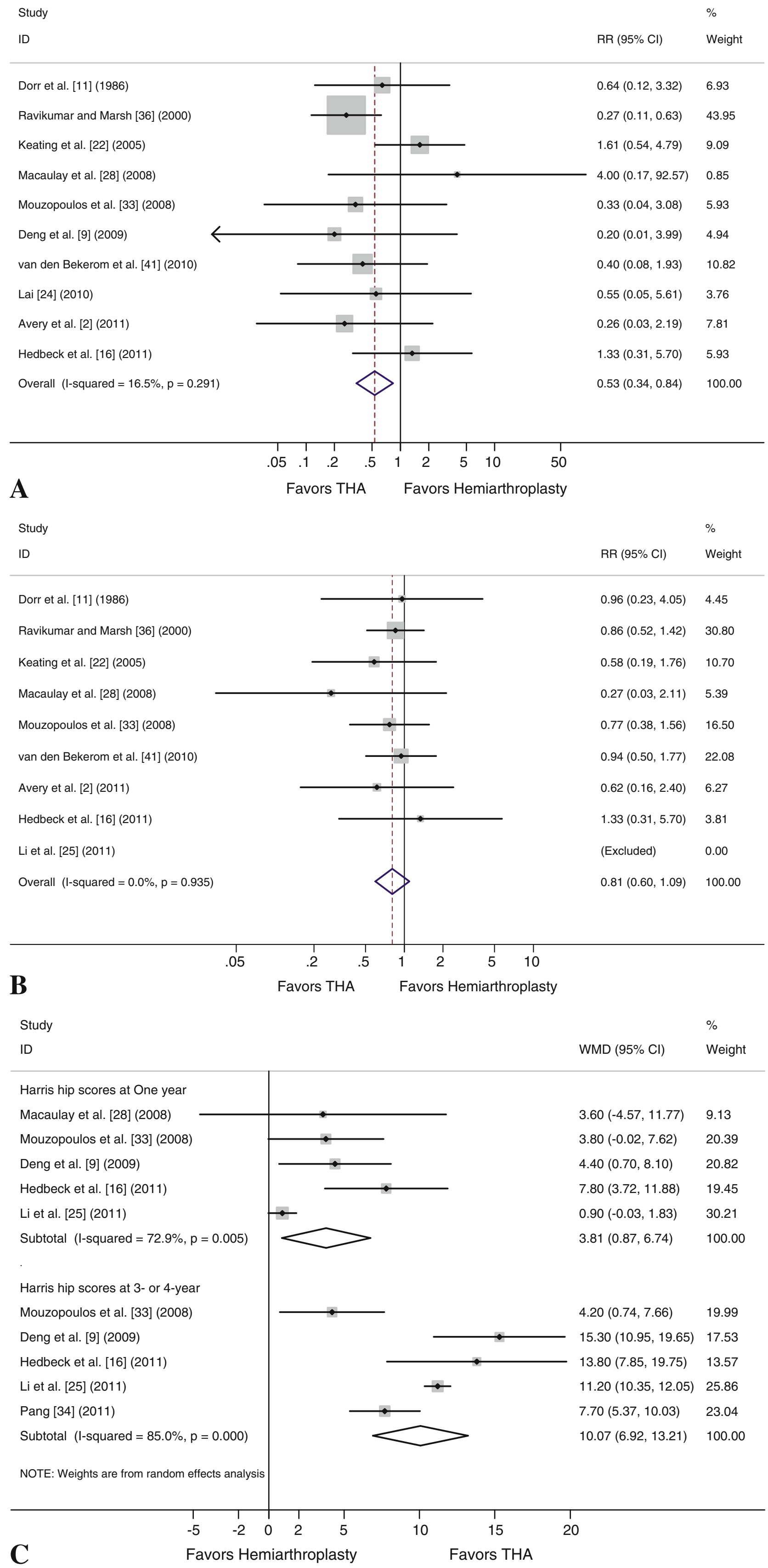

Fig. 3A–C Meta-analysis results are shown for the comparison of THA with hemiarthroplasty for displaced intracapsular hip fractures regarding efficacy. The forest plot shows pooled RRs with 95% CIs suggesting (**A**) THA is associated with lower rate of reoperations (analysis of 10 studies; fixed-effects model) and (**B**) THA is not associated with lower rate of mortality (analysis of nine studies; fixed-effects model). (**C**) A forest plot shows pooled WMDs with 95% CIs suggesting THA is associated with better hip function (analysis of six individual studies; random-effects model). RR = risk ratio; WMD = weighted mean difference.

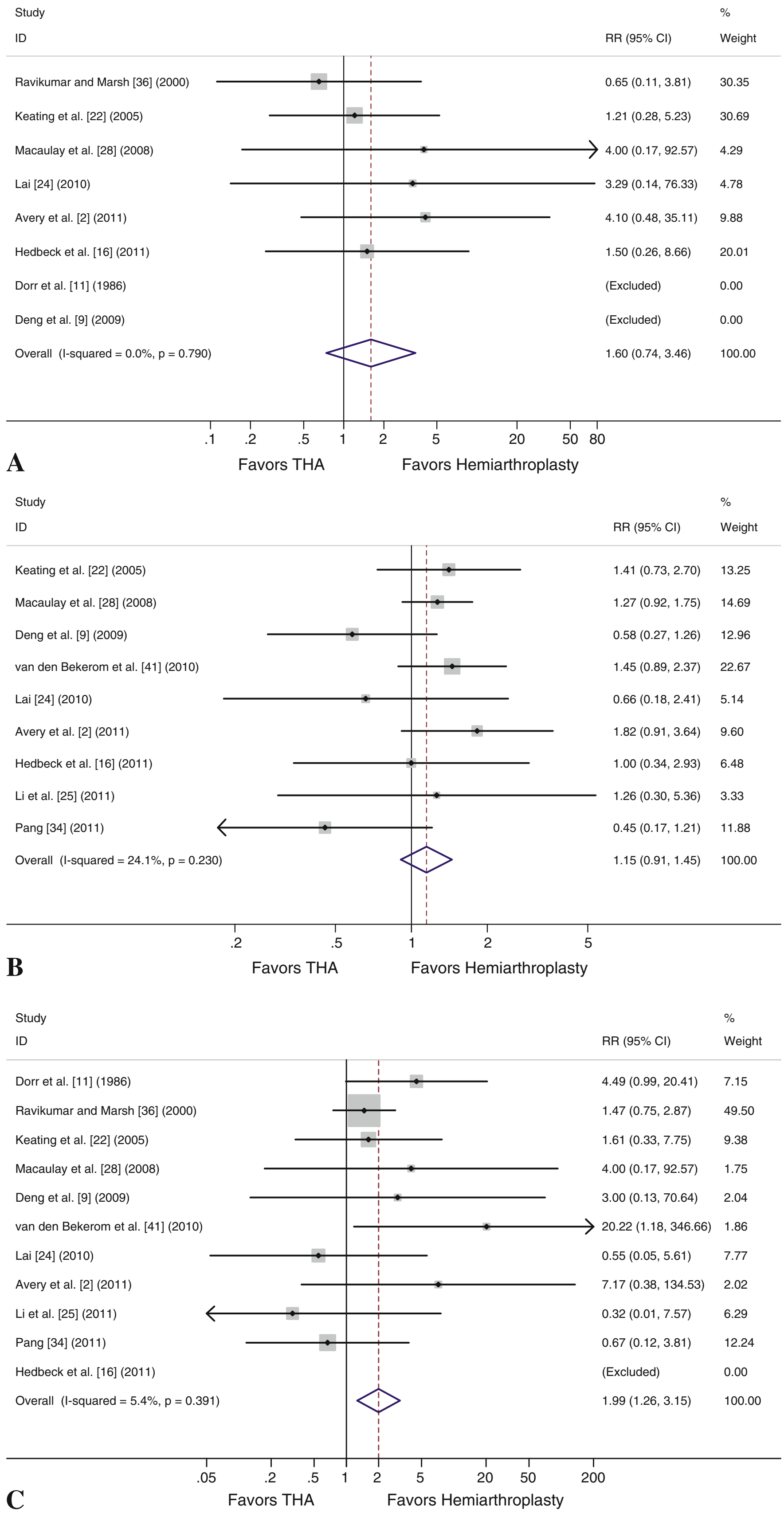

Fig. 4A–C Meta-analysis results are shown for the comparison of THA with hemiarthroplasty for displaced intracapsular hip fractures regarding complications. The forest plots show pooled RRs with 95% CIs suggesting (**A**) THA is not associated with lower rate of local infections (analysis of eight studies; fixed-effects model), (**B**) THA is not associated with lower rate of general complications (analysis of nine studies; fixed-effects model), and (**C**) THA is associated with higher rate of dislocations (analysis of 11 studies; random-effects model). RR = risk ratio.

papers. Therefore, additional studies could compare THA and hemiarthroplasty according to cemented or uncemented status independently. Third, a hemiarthroplasty might use unipolar or bipolar head components [13], and there also is need for an additional meta-analysis comparing unipolar or bipolar hemiarthroplasty with THA for patients with displaced femoral neck fractures independently. Fourth, owing to the lack of relative information, the risk of biases could not be well assessed and the outcomes from this study might be affected by risk of biases from those included studies (Supplemental Table 1; supplemental materials are available with the online version of CORR). Finally, RCTs using longer-term outcome assessments and more patient outcomes are needed to confirm the outcomes from this meta-analysis.

We included 12 RCTs (with a total of 1320 patients) in this meta-analysis. The meta-analysis showed THA was associated with a lower risk of subsequent reoperations compared with hemiarthroplasty and better ratings in the Harris hip scores, but there was no difference in mortality between patients undergoing THA and hemiarthroplasty. However, there was a tendency for a lower risk of mortality at 1 year in patients undergoing THA, and the sensitivity analysis showed the significance was changed by omission of one study [41], which indicated the credibility of this outcome was unstable and requires further studies with larger sample sizes.

Regarding complications, there was a higher risk of dislocation in patients undergoing THA, but there were no differences in local infections and general complications, confirming the findings reported by Hopley et al. [20]. This higher risk for dislocation should be well recognized and noted in clinical applications.

Although hemiarthroplasty is a quick and highly standardized procedure that allows for early weightbearing and recovery [30, 32, 38], we found it was associated with a higher risk of subsequent reoperations and lower mean Harris hip scores compared with THA. In addition, we found a tendency for a higher risk of mortality at 1 year in patients undergoing hemiarthroplasty. Therefore, hemiarthroplasty is inferior to THA for treatment of patients with displaced femoral neck fractures, and THA may have a larger role in the treatment of displaced femoral neck fractures than it has in the past.

In interpreting our results, the clinical and statistical significance of the findings should be considered. In this meta-analysis, THA can reduce the incidence of subsequent reoperations by 4.0% (4.6% with THA versus 8.6% for hemiarthroplasty), which is a relative risk reduction of approximately 50% (RR = 0.53; p = 0.006) and obviously suggests clinical and statistical significance. However, as THA seems to yield a higher risk of dislocation (7.6 % with THA versus 3.5% for hemiarthroplasty), the advantages of lower reoperation rate and higher Harris hip scores for THA must be traded off against the higher risk of dislocation, and THA may be more suitable for patients with more possibility of dislocation risk. Therefore, after weighing the advantages and disadvantages of THA in displaced femoral neck fractures compared with hemiarthroplasty, we recommend THA for displaced femoral neck fractures in patients with less possibility of dislocation risk.

Despite more dislocations, THA can benefit patients with displaced femoral neck fractures with a lower reoperation rate and higher functional scores.

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