

## Original Article

# Closed-suction drainage versus no drainage in total hip arthroplasty, a meta-analysis of randomized controlled trials

Pengfei Zan<sup>1\*</sup>, Weifeng Wang<sup>2\*</sup>, Lin Fan<sup>1\*</sup>, Zhong Wu<sup>1</sup>, Xiao Yu<sup>1</sup>, Tianyang Xu<sup>1</sup>, Guodong Li<sup>1</sup>

<sup>1</sup>Department of Orthopedics, The Tenth People's Hospital Affiliated with Tongji University, Shanghai, People's Republic of China; <sup>2</sup>Department of Clinical Laboratory, Central Laboratory, Jing'an District Centre Hospital of Shanghai (Huashan Hospital Fudan University Jing'an Branch), 200040 Shanghai, People's Republic of China.  
*\*Equal contributors and co-first authors.*

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**Abstract:** Purpose: The closed-suction drainage is widely used in total hip arthroplasty. However, controversy still exists regarding the use of closed-suction drainage after total hip arthroplasty. With this study, we intended to test whether the closed-suction drainage is safe and effective considering the clinical outcome measures. Methods: A comprehensive literature searching was performed in PubMed, MEDLINE, EMBASE and other internet database. All the relevant studies designed were retrieved to interpret this issue. The searching time frame was from the establishing of these databases until July 2015. Results: Twelve randomized controlled trials (RCTs) assessing a total of 1498 patients and 1524 hips were included. The results of our Meta-analysis indicate that the closed suction drainage prolongs the length of hospital stay and operation time, increases the amount of patients requiring for transfusion and the mean transfusion unit. However, it is encouraging that the drainage can decrease the wound related complications, patients of reinforcement and wound hematoma, lessen the change in mid-thigh circumference. No significant difference was found on other measurements, including blood loss, infection, volume of hematoma, DVT and PE and the Harris score. Conclusions: Based on the current evidence, the closed suction drainage though was still filled with controversy, it may supply more benefit aspects after THA. More carefully and scientifically designed RCTs are still required to further demonstrate the claim.

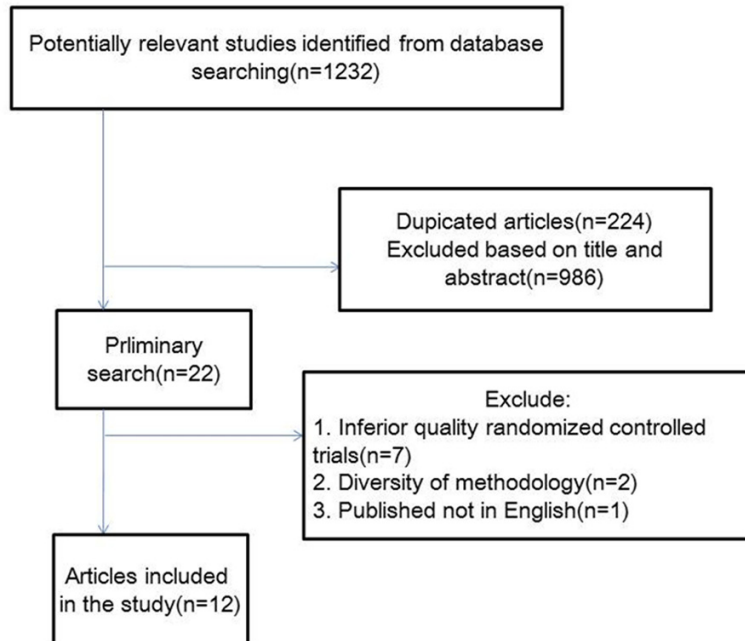
**Keywords:** Total hip arthroplasty, drainage, blood loss, complications, meta-analysis

## Introduction

Total hip arthroplasty (THA) is a successful procedure for relieving pain, correcting deformity and restoring function in cases with hip disorders such as osteoarthritis, femoral head necrosis. Traditionally, the postoperative closed-suction drainage has been widely used in all orthopedic surgery. It was based on a study by Waugh [1], who showed a lower infection rate when drainage was used. However, until now, the use of closed suction drainage in primary THA remains controversial. In theory, the closed suction drainage will prevent the formation of hematoma in the operative area, thus decrease tension of incision, diminish delayed wound healing and reduce the risk of infection [2-4]. To the contrary, some studies claimed that the closed-suction drainage can lead to

more blood loss after THA, because it eliminates the tamponade effect and may cause retrograde infection as well [5, 6].

Since it was first introduced, the closed-suction drainage has received a boost of concentration in the area of THA. A variety of studies were conducted to identify this issue, including prospective RCTs, retrospective studies, meta-analysis and systematic review, while, no final conclusion has been drawn. The latest meta-analysis concentrating on the closed suction drainage in THA was published by Chen et al. [7], who drew the conclusion that there is insufficient evidence to support the routine use of closed-suction drainage in hip arthroplasty. And at the same time, it increased requirement for postoperative blood transfusion. However, this study included some quasi-randomized trials,



**Figure 1.** Flow chart of the studies identified in the meta-analysis.

pared closed suction drainage with no drainage after THA. Two independent reviewers carried out a systemic computerized searching of electronic databases including PubMed, the Cochrane Library, MEDLINE, EMBASE and other intent databases. In addition, the internet searching engine “Google” was also searched. The key words used for the search included “total hip replacement”, “total hip arthroplasty”, “THR”, “THA”, “closed suction drainage”, “drainage”, “drain” and “non-drainage”. The search was not restricted time of the articles published.

## *Inclusion and exclusion criteria*

and there was a moderate possibility of selection bias and publication bias, the conclusion should be dealt with caution. Since then, some new RCTs have been conducted, it is necessary to engage a new meta-analysis excluding some inferior quality studies and containing the latest RCTs to re-recognize the debate.

We therefore conducted a study of all available high-quality RCTs comparing closed-suction drainage with no drainage in THA to evaluate the safety and efficacy considering clinical outcome measures of this aspect in the procedure.

## **Materials and methods**

The meta-analysis were conducted according to the methodological guidelines outlined by the Cochrane Collaboration (Oxford, UK) [8]. All data were reported according to the Quality of Reporting of Meta-Analyses (QUOROM) statement provided by the Handbook for Systematic Reviews of Interventions version 5.0.0 [9]. The quality of reporting of randomized controlled trial’s checklist of items was also used to quantify all the final studies included in our meta-analysis were identified.

### *Literature search*

A comprehensive literature searching was performed to identify all published RCTs that com-

The literatures were identified that met the following inclusion criteria: (1) published high-quality RCTs (the CONSORT score  $\geq 11$ ); (2) comparison of closed suction drainage and no drainage after THA surgery; (3) patients undergoing a primary THA; (4) outcome measurements should include at least one of these parameters (blood loss, blood transfusion, length of hospital stay, hip function, infection, wound hematoma and other complications). Exclusion criteria were as follows: (1) unpublished data, (2) proceedings of conference, (3) nonrandomized controlled trials (4) inferior quality RCTs (5) publication language not in English and (6) cadaver model or animal experiments.

### *Article selection and validity assessment*

RCTs were included that comparing closed suction drainage and no drainage after THA. The blood loss, blood transfusion and incidence of complications were regarded as primary outcomes. The secondary outcome measurements included operation time, length of hospital stay, VAS score, hip ROM, Harris score, dressing change. Inappropriate articles were filtered out by scanning the title of each study. Afterwards, abstracts of the remained studies were reviewed independently, and those potentially relation to our meta-analysis were select-

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**Table 1.** The data pool of included studies (drainage/no drainage)

Study (year)	Pa-tients	Hips	Drainage removed (h)	Hospital stay (d)	Operation time (min)	Total BL (ml)	Intraop-erative BL (ml)	Postoperative Drainage (ml)	Patients transfu-sion (n)	Transfusion unit (u)	Change in mid-thigh circum-stance (cm)	Pain (VAS)	Region	Con-sort score
Zeng W 2014 [2]	168	83/85	24	10.5 (1.5)/ 10.2 (1.4)	nc	nc	271.2 (68.6)/ 254.4 (71.1)	359.2 (216.2)	8/7	3.8 (0.7)/ 2.9 (1.1)	nc	nc	Sichuan, China	19
Strahovnik <sup>1</sup> 2010 [3]	139	46/42	24	7 (4-14)/ 7 (7-14)	85 (55-150)/ 90 (60-150)	959 (717-1202)/ 1052 (923-1181)	nc	200 (156-243)	nc	635 (489-782)/ 466 (329-585) ml	2.2 (1.3-2.8)/ 4.5 (3.4-5.6)	3/14	Celje, Slovenia	17
Strahovnik <sup>2</sup> 2010 [3]		51/42	48	7 (5-14)/ 7 (7-14)	90 (45-165)/ 90 (60-150)	1098 (812-1383)/ 1052 (923-1181)	nc	395 (334-457)	nc	647 (490-804)/ 466 (329-585) ml	2.7 (1.9-3.4)/ 4.5 (3.4-5.6)	4/14	Celje, Slovenia	17
Roth 2010 [4]	80	40/40	24	nc	33 (29-41)/ 30.8 (25-38)	900 (300-2400)/ 900 (300-2100)	nc	nc	0/0	0/0	0.8 (-2.5)/ 1.2 (-2.9)a 1.3 (-3.7)/ 2.1 (-1-10.5)b	2/1.2 (d1, rest) 3.8/2.7 (d1, stress) 0.6/0.3 (d4, rest) 2.2/1.4 (d4, stress)	Munich, Germany	13
Walmsley 2005 [5]	552	257/ 272	24	10/10	nc	nc	nc	nc	93/78	nc	nc	nc	Dunfer-mline, UK	16
Kim 1998 [25]	48	48/48	24	nc	nc	nc	nc	nc	nc	nc	nc	nsd	Seoul, Korea	12
Dora 2007 [26]	100	50/50	48	nc	nc	2346 (1034)/ 2195 (1110)	nc	97 (138)	nc	2.4 (1.6)/ 2.5 (1.9)	2.6 (3.1)/ 2.5 (3.4)c 1.0 (2.7)/ 0.6 (2.4)d	1.9 (1.5)/ 1.8 (1.6) (d2) 1.8 (1.6)/ 2.0 (1.5) (d6)	Zürich, Switzerland	19
Cheung 2010 [27]	100	52/48	24	7 (5.3-9)/ 6 (5-7)	nc	nc	300 (200-400)/ 300 (250-350)	350 (113-558)	19/6	nc	nc	nc	Shropshire, UK	18
Ovadia 1997 [28]	30	18/12	48	10.05 (3.5)/ 8.33 (0.88)	nc	nc	nc	nc	9/2	nc	nc	nc	Tel-Aviv, Israel	14
González 2004 [29]	103	53/51	Double 24	5.1 (4-10)/ 4.7 (3-7)	97/100	nc	nc	290 (50-550)	21/18	1.6 (1-3)/ 1.5 (1-3)	1.6(-2.5)/ 1.7(-5-8)	nc	New York, USA	17
Kleinert 2012 [30]	80	40/40	48	6.6 (1.0)/	nsd	nsd	nc	nc	4/4	nc	3.8(2.3)/	1.4 (1.9)/2.1 (1.7) (d1)	Zurich, Switzerland	19

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				5.4 (1.0)						5.3(2.5)	1 (1.5)/1.4 (2.3) (d2) 0.7 (1.2)/0.7 (1.2) (d3)			
Matsuda 2006 [31]	40	20/20	48	nc	83.5 (11.8)/	nc	328 (92)/	416 (55-1001)	nc	nc	nc	nc	Tokyo, Japan	18
					87.2 (11.9)		311 (96)							
Niskanen 2000 [32]	58	27/31	24	nc	100 (69- 140)/	588 (200- 1400)/	nc	420 (100- 1180)	nc	nc	nc	nc	Lahti, Finland	12
					97 (63-250)	612 (200-1100)								

Nc = not clear, nsd = no significant difference and without detailed data. VAS = visual analogue scale. BL = blood loss. a = thigh swelling 10 cm below surgical area, b = thigh swelling 20 cm below surgical area. c = 20 cm above patella, d = 10 cm above patella. Blood transfusion, 1U = 200 ml.

**Table 2.** The data pool complications of included studies (drainage/no drainage)

Study (year)	Hips	Infections	Ecchymosis	Wound hematoma	Volume of hematoma	Reinforcement	DVT and PE	ROM	Harris score	Total wound complications
Zeng W 2014 [2]	83/85	2/9	3/11	0/0	3.0 (1.3)/ 5.1 (2.0) mm	nc	0/0	A	nc	9/34
Strahovnik <sup>1</sup> 2010 [3]	46/42	1/0	nc	0/1	nc	2/20	0/0	nc	nc	1/2
Strahovnik <sup>2</sup> 2010 [3]	51/42	0/0	nc	0/1	nc	2/20	0/0	nc	nc	2/2
Roth 2010 [4]	40/40	nc	nc	nc	40.1 (0-514)/ 43.7 (0-343) cm-	nc	0/0	nc	nc	0/0
Walmsley 2005 [5]	257/272	19/23	nc	0/1	nc	nc	5/2	nc	nsd	19/24
Kim 1998 [25]	48/48	0/0	3/11	35/44	nc	nc	nc	nsd	nsd	35/44
Dora 2007 [26]	50/50	0/0	nc	nc	1.9 (4.1)/ 0.94 (3.4)a 2.6 (3.3)/ 8.0 (17.0)b	nc	1/1	nc	nsd	0/0
Cheung 2010 [27]	52/48	2/0	nc	nc	nc	nc	nc	nc	nc	2/0
Ovadia 1997 [28]	18/12	0/0	0/0	nc	nc	nc	0/0	nc	nc	3/2
González 2004 [29]	53/51	2/0	nc	2/0	nc	6/10	2/1	nc	nc	4/0
Kleinert 2012 [30]	40/40	0/0	nc	nc	3.8 (2.3)/ 5.3 (14.8) cm <sup>3</sup>	nc	nc	nc	88 (60-98)/ 88 (65-99) nsd	2/4
Matsuda 2006 [31]	20/20	0/0	0/0	nc	nc	nc	0/0	nc	nc	2/6
Niskanen 2000 [32]	27/31	1/1	nc	nc	nc	9/21	0/0	90 (50-120)/ 95 (70-110)c	nc	2/3

Nc = not clear, nsd = no significant difference and without detailed data. DVT deep vein thrombosis, PE pulmonary embolism. ROM = range of motion. A: The range of motion was better in the early time (less than 2 weeks) in the drainage group, after 1 month, there was no significant difference. a = subcutaneous hematoma on day 6 (cm<sup>3</sup>), b = subfascial hematoma on day 6 (cm<sup>3</sup>). c = angle of hip flexion.

ed. Bibliographies of the studies were reviewed for any additional ones. Finally, the consolidated standards of reporting trials (CONSORT) checklist [10] were used to perform a detailed appraisal of validity and quality of the potentially eligible studies. A 22-item checklist was used to help appraisal of the RCTs. Using the guideline, the absence or presence of the item in each study was scored 0 or 1, respectively, giving a score out of 22. Each article was identified and scored by two members of the review team independently. A score of 50% (11/22) was defined as a lower limit for inclusion. This percentage was used because this has been reported as the average CONSORT score for surgical studies [11]. All disagreements were settled by discussion between team-workers.

## Data extraction

Data of outcome measurements were extracted from each study independently and checked by a third author against the anthropic mistakes of original information. Whenever necessary, we contacted the authors via e-mail for the missing data and additional information. In a study reported by Strahovnik [3], the one hundred thirty-nine patients undergoing total hip arthroplasty were randomized into 3 groups: 42 patients received no drainage, 46 patients received drainage for 24 hours, and 51 patients received drainage for 48 hours. We dealt this study with two groups of data. It was presented in the Tables and Figures as Strahovnik1 and Strahovnik2. For any disaccord, a consensus was reached by discussion. Data extracted from each study included publication information; participant demographics; sample size; the time of removing drainage; operation time; length of hospital stay; intraoperative blood loss; total blood loss; volume of drainage; change in mid-thigh circumference; patient needing for reinforcement; patients requiring of transfusion; amount of transfusion unit; volume of hematoma; wound hematoma; DVT and PE; all wound related complications; pain and VAS score; Harris score. The total wound related complications included superficial infection, deep infection, oozing, ecchymosis, tension vesicle, wound dehiscence, seroma, delayed wound healing, hematoma, wound persistent leaking, excessive swelling, heterotopic ossifications and thigh pain with apparent swelling, which were reported in the studies.

## Statistical analysis

The meta-analysis was conducted using the RevMan 5.2 software (Cochrane Collaboration, Oxford, UK). The inverse variance method was used for continuous measurements, and the Mantel-Haenszel method for dichotomous measurements. Heterogeneity between the included studies was tested by using a standard Chi-square test (with a level of significance of  $P = 0.1$ ) as well as the  $I^2$  statistic. An  $I^2$  statistic value of  $>50\%$  was considered a substantial heterogeneity. The random effects model described by DerSimonian [12] was used for the continuous data with substantial heterogeneity in order to gain meaningful confidence intervals; otherwise, the fixed-effects model described by Lau [13] was used. When significant heterogeneity presented, we also performed subgroup analysis and sensitivity analysis. If the standard deviation of a mean was not reported in a study, it was calculated by the range with use of the methods proposed by Hozo et al [14]. The pooled effect of the  $P$  value  $<0.05$  was considered significant.

## Results

A flow chart of the studies identified was shown in the flow diagram (**Figure 1**). Of the 1232 articles retrieved by the search, 224 studies were duplicated and 986 studies were excluded based on the title and abstract, leaving 22 potentially relevant studies. After detailed evaluation, seven studies were excluded based on the CONSORT score [15-21], two studies were with diversity of the methodology [22, 23], one was published in French [24]. Finally, twelve studies were included in our Meta-analysis. The mean CONSORT adherence score of the studies was 16.2 (median 12-19) of a maximum score of 22. **Tables 1** and **2** show the included studies with their contributions to the data pool [2-5, 25-32].

## Outcome analysis

The results of the Meta-analysis for the clinical outcomes are shown in the relevant forest plots (**Figures 2-4, 6-9**). And the funnel plot shows the publication bias (**Figure 5**).

## Length of hospital stay and operation time

Combining the results of the seven groups of data [2, 3, 27-30] in which the length of hospi-

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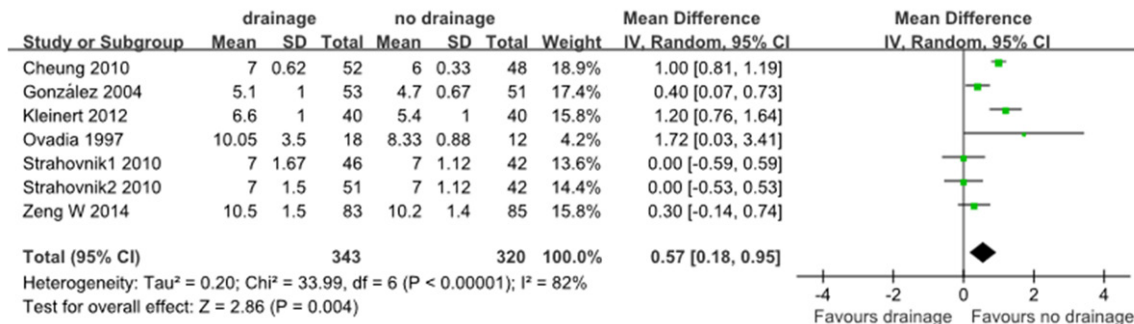


Figure 2. Forest plot of the length of hospital stay.

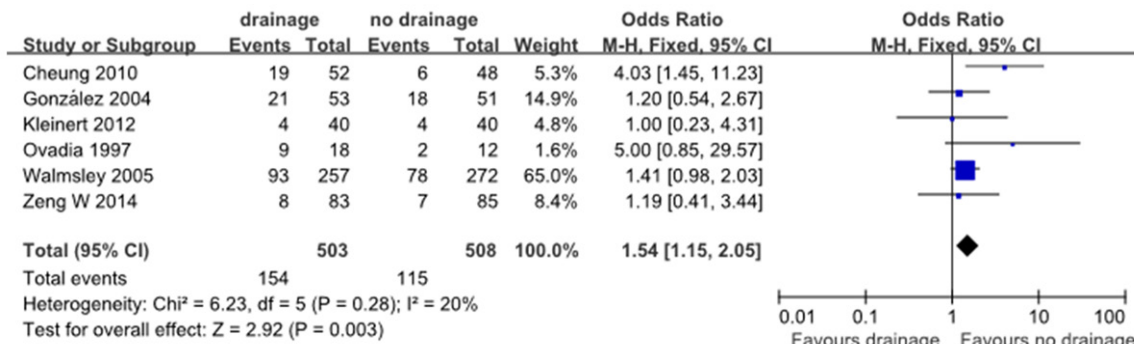


Figure 3. Forest plot of patients requiring for transfusion.

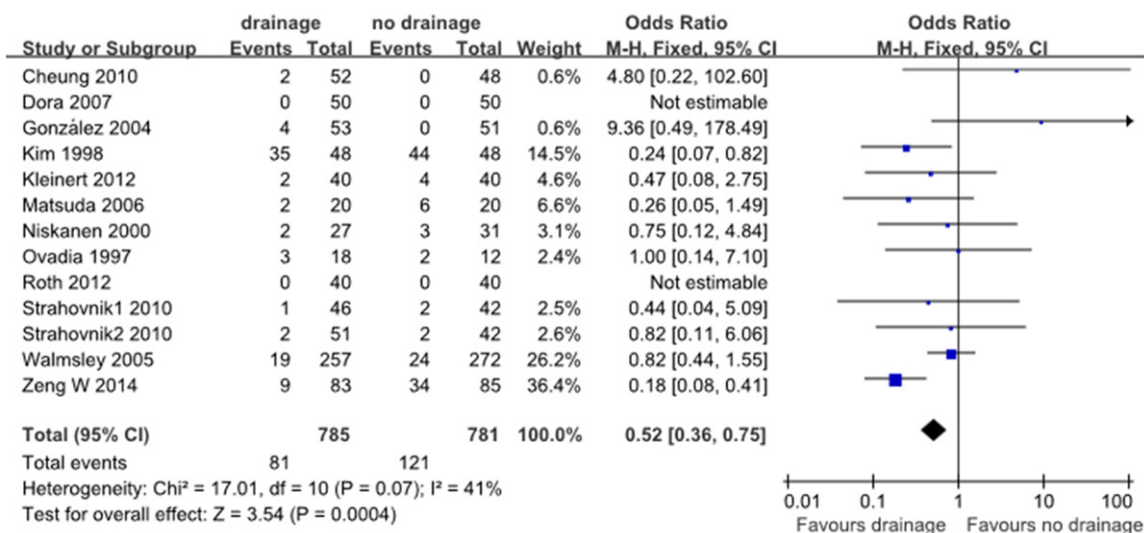
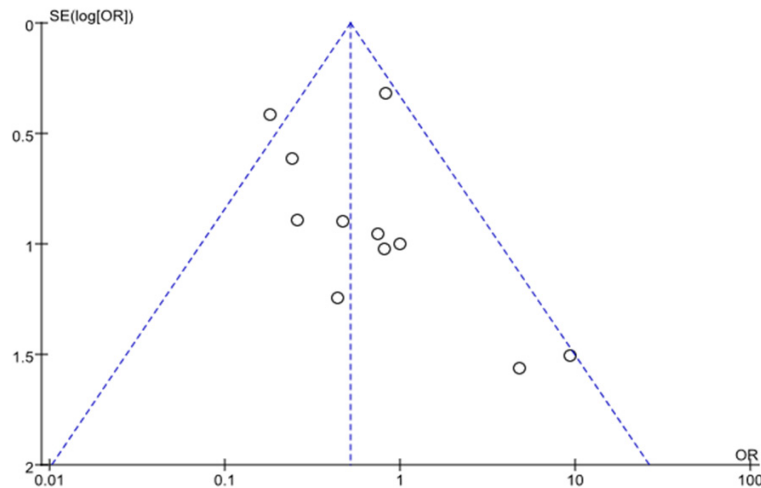


Figure 4. Forest plot of total wound related complications.

tal stay was revealed, it was much shorter in the no drainage group (mean difference = 0.57 d; 95% confidence interval = 0.18 to 0.95;  $P = 0.004$ ) (Figure 2). The subgroup analysis and sensitivity analysis also showed a significant

difference. Of the five groups of data [3, 4, 31, 32] revealing the operation time, it was much longer in the drainage group (mean difference = 1.94 min; 95% confidence interval = 1.05 to 2.83;  $P < 0.0001$ ).





**Figure 5.** Funnel plot of the complications data of the studies.

#### Blood loss and transfusion

A total of five groups of data [3, 4, 26, 32] were included for analysis of the total blood loss and showed no significant difference between the drainage and no drainage group (mean difference = -11.61 ml [-108.04, 84.83]; 95% confidence interval = -108.04 to 84.83;  $P = 0.81$ ). In three studies [2, 27, 31], the intraoperative blood loss was reported, also showed no significant difference (mean difference = 3.52 ml; 95% confidence interval = -5.56 to 12.60;  $P = 0.45$ ). However, when combining the results of six studies [2, 5, 27-30], in which the patients requiring for transfusion was reported, a significant difference was found (odds ratio = 1.54; 95% confidence interval = 1.15 to 2.05;  $P = 0.003$ ) (**Figure 3**). Five groups of data involving the transfusion unit [2, 3, 26, 29], which also showed more transfusion unit in the no drainage group (mean difference = 0.59 u; 95% confidence interval = 0.22 to 0.95;  $P = 0.001$ ).

#### Complications

All studies involved complications during THA, the overall incidence wound related complications was 13.1% (200/1524). **Figure 4** showed that there was a significant difference between drainage and no drainage group (odds ratio = 0.52; 95% confidence interval = 0.36 to 0.75;  $P = 0.0004$ ). A funnel plot of the complications data of the twelve studies showed low publication bias (**Figure 5**). When came to the infections, six studies [2, 3, 5, 27, 29, 32] involved the data, no significant difference was found

between the groups (odds ratio = 0.85; 95% confidence interval = 0.51 to 1.42;  $P = 0.53$ ) (**Figure 6**). Of the five groups of data [3, 5, 25, 29] involving the patients with wound hematoma, a significant difference was found between the drainage and no drainage group (odds ratio = 0.40; 95% confidence interval = 0.17 to 0.95;  $P = 0.04$ ) (**Figure 7**). The volume of the hematoma was measured by ultrasound in four studies [2, 4, 26, 30], the methods of hematoma measured were different between the studies, irrespective of the unit of

measurement, combining the results showed no significant difference between the groups (mean difference = -1.47; 95% confidence interval = -3.72 to 0.78;  $P = 0.20$ ).

The complication of DVT and PE was reported in three studies [5, 26, 29], no significant difference was found (odds ratio = 2.07; 95% confidence interval = 0.62 to 6.94;  $P = 0.24$ ).

#### Change in mid-thigh circumference and patients needing for reinforcement

Five studies [3, 4, 26, 29, 30] with 8 groups of data reported the change in mid-thigh circumference, the methods of measurement were also different between the studies, irrespective of the position of measurement, when combined the results, it showed a significant difference between the groups (mean difference = -0.94; 95% confidence interval = -1.46 to -0.42;  $P = 0.0004$ ). However, the studies were with a considerable heterogeneity (**Figure 8**). A significant difference also existed when subgroup analysis and sensitivity analysis was performed. Three studies [3, 29, 32] with four groups of data involved the patients needing for reinforcement, a significant difference was found between the groups (odds ratio = 0.14; 95% confidence interval = 0.04 to 0.47;  $P = 0.001$ ) (**Figure 9**).

#### Other measurements

A total of four studies [3, 4, 26, 30] involved pain measurement between the drainage and

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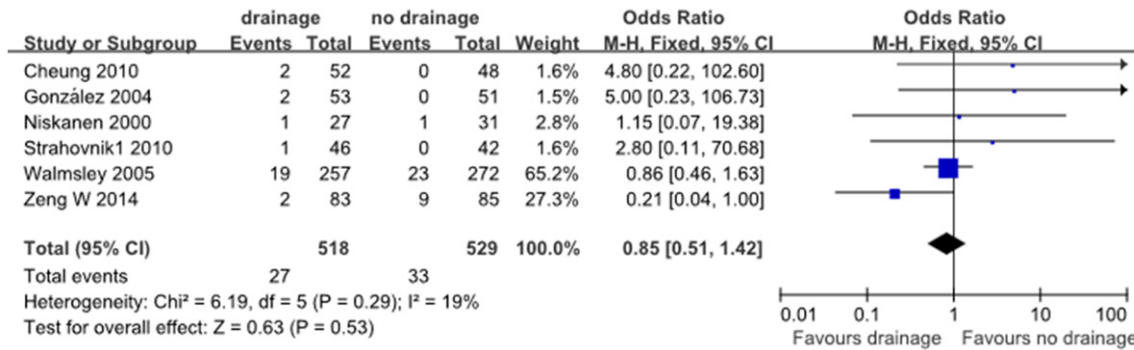


Figure 6. Forest plot of infections.

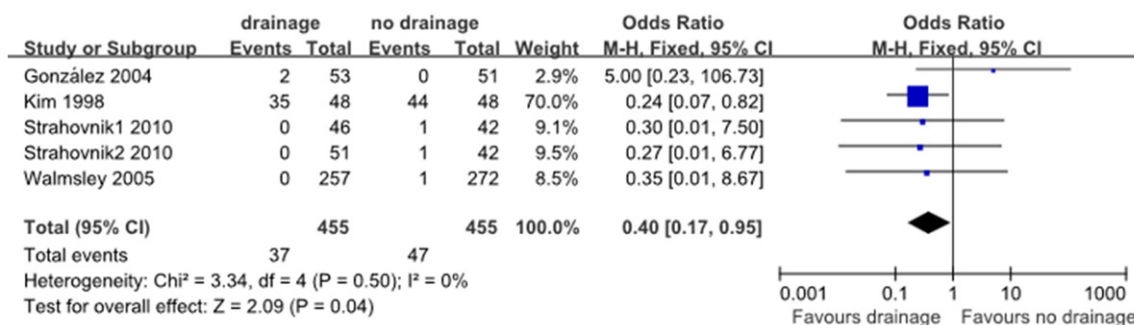


Figure 7. Forest plot of wound hematoma.

no drainage group after THA, it was difficult for us to perform the analysis on pain because of the different measured methods and kinds of data given. In a study reported by Roth [4], pain was recorded through VAS score at rest and under stress on postoperative day 1 and day 4 respectively. The drainage group patients were reported significantly more pain both at rest and under stress on postoperative day 1 and day 4. Strahovnik's study [3] reported 14 patients in the no drainage group, 3 patients in the 24 h drainage group and 4 patients in the 48 h drainage group suffering mid-thigh pain, the difference was significant ( $P = 0.01$ ). In Kleinert's study [30], the pain VAS score was measured on day 1, day 2 and day 3 postoperatively; in Dora's study [26], the pain VAS score was measured on day 2 and day 6 postoperatively, no significant difference was found. Three studies [2, 25, 32] reported the range of motion of the hip between the groups, in Zeng W's study [2], the range of motion was better in the early time (less than 2 weeks) in the drainage group, after 1 month, there was no significant difference. The other two studies both found no significant difference during the fol-

low-up times. When came to the Harris score, four studies [5, 25, 26, 30] recorded the result, it was difficult for us to perform the analysis. As a consistent result, they all found no significant difference.

### Discussion

It was in the 19th century, the closed suction was first used postoperatively [33], and it was traditionally used in all orthopedic surgery based on a study by Waugh [1], the THA was included as well. However, recently, many surgeons proposed some harmful aspects of the closed suction drainage, which made the traditional procedure be filled with controversy. This Meta-analysis demonstrated that the closed-suction drainage prolonged the length of hospital stay and operation time, increased the amount of patients requiring for transfusion and the mean transfusion unit. However, it was encouraging that the drainage could decrease the wound related complications, patients of reinforcement and wound hematoma, lessen the change in mid-thigh circumstance. There was no difference between the groups regard-



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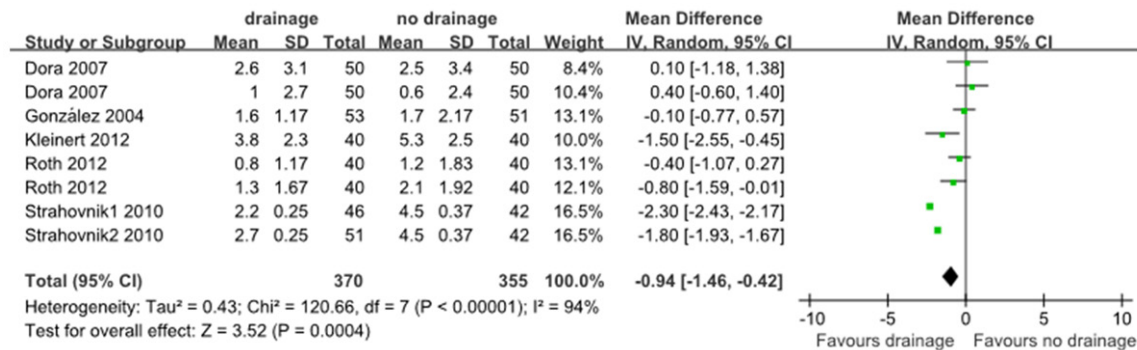


Figure 8. Forest plot of change in mid-thigh circumference.

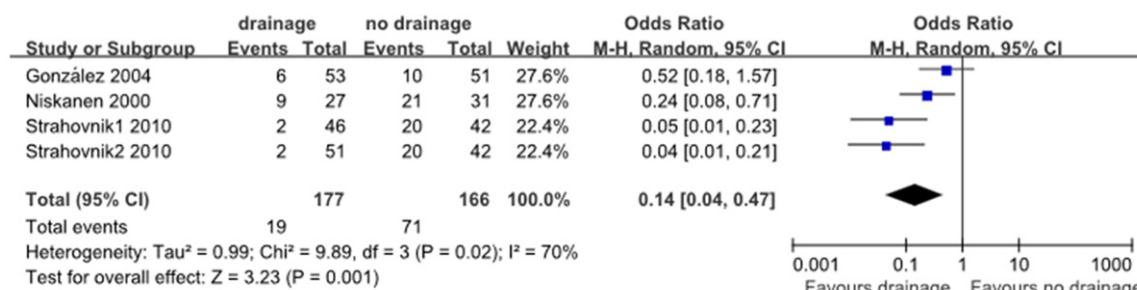


Figure 9. Forest plot of patients needing for reinforcement.

ing other measurements, including blood loss, infection, volume of hematoma, DVT and PE and the Harris score.

Blood loss and blood transfusion are key primary clinical outcome measurements in THA, in our study, a significant advantage for patients with no drainage was the decreasing amount of patients requiring homologous transfusion and the mean transfusion unit. However, no significant difference was found on intraoperative and total blood loss between the groups. The reporting of total blood loss was variable amongst the studies, it is important to point out that total blood loss included both visible blood loss and hidden blood loss [34, 35]. Many measured the visible blood loss in 24 h postoperatively and included the drain volume. Only two studies used a more accurate method which was proposed by GROSS [36]. This brought a considerable heterogeneity to the result. The patients requiring homologous transfusion was a favorite reaction to the blood loss. The combining of persistent drainage and the deficiency of tamponade effect in the drainage group resulted in an excess blood loss.

The closed suction drainage was based on the theory of effectively decreasing the hematoma formation, which was theoretically associated with decreasing the limb swelling and preventing occurrence of infections. However, some authors have advocated that the drainage can lead to potential retrograde infection. Therefore, the incidence of infection was the primary outcome which indicated no statistically significant difference between the groups. The incidence of infection was 3.44% in the drainage group and 4.47% in the no drainage group. This incidence should be dealt with caution because of the relatively small sample.

The wound related complications were strongly linked with drainage and no drainage, which were considered as important outcome measurements, the forest plot of the wound related complications showed a significant more incidence in the no drainage group. The closed suction drainage was an effective method for decreasing the hematoma formation, our results showed a reduction of patients requiring reinforcement; patients of wound hematoma and less changing in mid-thigh circumference, which all supported the point. The

increased hematoma formation in the no drainage group could increase the wound tension and decrease the perfusion of the tissues, and also it provided an ideal medium for bacterial culture, which was harmful for wound healing. Therefore, in view of the possible complications as above, surgeons should select closed-suction drainage to minimize the potential complications. If the drainage was not employed, surgeons should pay attention to some wound related complications.

Based on the results of our meta-analysis, we suggested that patients must be evaluated carefully postoperatively. If the patients' clinical manifestation showed severe anemia, we hope drainage was not employed to decrease blood loss and the requirement for transfusion. If the general condition of the patients were just perfect, we hope the closed-suction drainage was used to decrease the risk of related complications. However, it was not absolute, the manipulation of the drainage depended more on a surgeon's experience and habit.

### *Limitations*

Some limitations must be recognized in our meta-analysis. (1) The small sample size of this analysis is a major limitation. We could not perform statistical tests to eliminate the publication bias. (2) The skills of different surgeons can influence the clinical outcomes, and in order to avoid surgeon bias, a standard was required to assess the surgery skills. (3) Some studies failed to give sufficient and usable data, and some continuous data was reported as mean without present SD, which was difficult for us to analyze. (4) The methodology of the studies made some of our analysis a considerable heterogeneity. However, though there are some limitations mentioned above, our study has several strengths. We excluded some inferior quality RCTs, the included studies are RCTs with the highest level of evidence. The numerous biases could be minimized by our comprehensive search, duplicate selection process, and strict inclusion and exclusion criteria.

### **Conclusion**

Our Meta-analysis of the available RCTs indicates that the closed-suction drainage have dual characters. We hope our Meta-analysis

presented here will enable surgeons to make an informed decision whether to use the closed-suction drainage after THA or not. Based on the current evidence, the closed-suction drainage though was still filled with controversy, it may supply more benefit aspects after THA. More carefully and scientifically designed randomized controlled trials are required to further demonstrate the claim.

### **Disclosure of conflict of interest**

None.

**Address correspondence to:** Guodong Li, Department of Orthopedics, The Tenth People's Hospital Affiliated with Tongji University, 301 Yanchang Rd, Shanghai 200072, People's Republic of China. Tel: +86-13816305037; Fax: +86-21-56305592; E-mail: litrue2004@163.com

### **References**

- [1] Waugh TR, Stinchfield FE. Suction drainage of orthopaedic wounds. *J Bone Joint Surg* 1961; 43: 939-1021.
- [2] Zeng WN, Zhou K, Zhou ZK, Shen B, Yang J, Kang PD, Pei FX. Comparison between Drainage and Non-drainage after Total Hip Arthroplasty in Chinese Subjects. *Orthop Surg* 2014; 6: 28-32.
- [3] Strahovnik A, Fokter SK, Kotnik M. Comparison of drainage techniques on prolonged serous drainage after total hip arthroplasty. *J Arthroplasty* 2010; 25: 244-248.
- [4] Philipp von Roth M, Perka C, Dirschedl K, Mayr HO, Preininger B, Hube R. Use of redon drains in primary total hip arthroplasty has no clinically relevant benefits. *Orthopedics (Online)* 2012; 35: e1592.
- [5] Walmsley P, Kelly M, Hill R, Brenkel I. A prospective, randomised, controlled trial of the use of drains in total hip arthroplasty. *J Bone Joint Surg* 2005; 87: 1397-1401.
- [6] Esler C, Blakeway C, Fiddian N. The use of a closed-suction drain in total knee arthroplasty a prospective, randomised study. *J Bone Joint Surg* 2003; 85: 215-217.
- [7] Chen ZY, Gao Y, Chen W, Li X, Zhang YZ. Is wound drainage necessary in hip arthroplasty? A meta-analysis of randomized controlled trials. *Eur J Orthop Surg Traumatol* 2014; 24: 939-946.
- [8] Higgins JP, Green S. *Cochrane handbook for systematic reviews of interventions*. Wiley Online Library 2008.
- [9] Moher D, Cook DJ, Eastwood S, Olkin I, Rennie D, Stroup DF, Group Q. Improving the quality of

- reports of meta-analyses of randomised controlled trials: the QUOROM statement. *Lancet* 1999; 354: 1896-1900.
- [10] Moher D, Schulz KF, Altman DG. The CONSORT statement: revised recommendations for improving the quality of reports of parallel group randomized trials. *BMC Med Res Methodol* 2001; 1: 2.
  - [11] Rosin RD. Perspectives on this issue of the IJS. *Int J Surg* 2011; 9: 361-362.
  - [12] DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials* 1986; 7: 177-188.
  - [13] Lau J, Ioannidis JP, Schmid CH. Quantitative synthesis in systematic reviews. *Ann Inter Med* 1997; 127: 820-826.
  - [14] Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. *BMC Med Res Methodol* 2005; 5: 13.
  - [15] Murphy J, Scott J. The effectiveness of suction drainage in total hip arthroplasty. *J Royal Soc Med* 1993; 86: 388.
  - [16] Cobb J. Why use drains? *J Bone Joint Surg* 1990; 72: 993-995.
  - [17] Ritter MA, Keating EM, Faris PM. Closed wound drainage in total hip or total knee replacement. A prospective, randomized study. *J Bone Joint Surg* 1994; 76: 35-38.
  - [18] Widman J, Jacobsson H, Larsson SA, Isacson J. No effect of drains on the postoperative hematoma volume in hip replacement surgery: a randomized study using scintigraphy. *Acta Orthop* 2002; 73: 625-629.
  - [19] Beer KJ, Lombardi A, Mallory T, Vaughn B. The efficacy of suction drains after routine total joint arthroplasty. *J Bone Joint Surg* 1991; 73: 584-587.
  - [20] Crevoisier X, Reber P, Noesberger B. Is suction drainage necessary after total joint arthroplasty? *Arch Orthop Trauma Surg* 1998; 117: 121-124.
  - [21] Ravikumar K, Alwan T, Fordyce M, Tuson K. Drainage versus non-drainage in total hip arthroplasty. A prospective randomised study. *Hip Int* 2001; 11: 49-54.
  - [22] Johansson T, Engquist M, Pettersson LG, Lisander B. Blood loss after total hip replacement: a prospective randomized study between wound compression and drainage. *J Arthroplasty* 2005; 20: 967-971.
  - [23] Rollo VJ, Hozack WJ, Rothman RH, Chao W, Eng KO. Prospective randomized evaluation of blood salvage techniques for primary total hip arthroplasty. *J Arthroplasty* 1995; 10: 532-539.
  - [24] Mengal B, Aebi J, Rodriguez A, Lemaire R. [A prospective randomized study of wound drainage versus non-drainage in primary total hip or knee arthroplasty]. *Revue De Chirurgie Orthop ÉDique Et RÉParatrice De L'appareil Moteur* 2001; 87: 29-39.
  - [25] Kim YH, Cho SH, Kim RS. Drainage versus non-drainage in simultaneous bilateral total knee arthroplasties. *Clin Orthop Relat Res* 1998; 347: 188-193.
  - [26] Dora C, von Campe A, Mengiardi B, Koch P, Vienne P. Simplified wound care and earlier wound recovery without closed suction drainage in elective total hip arthroplasty. A prospective randomized trial in 100 operations. *Arch Orthop Trauma Surg* 2007; 127: 919-923.
  - [27] Cheung G, Carmont MR, Bing A, KUipER JH, Alcock RJ, Graham NM. No drain, autologous transfusion drain or suction drain? A randomised prospective study in total hip replacement surgery of 168 patients. *Acta Orthopædica Belgica* 2010; 76: 619-627.
  - [28] Ovadia D, Luger E, Bickels J, Menachem A, Dekel S. Efficacy of closed wound drainage after total joint arthroplasty: a prospective randomized study. *J Arthroplasty* 1997; 12: 317-321.
  - [29] Della Valle AG, Slullitel G, Vestri R, Comba F, Buttaro M, Piccaluga F. No need for routine closed suction drainage in elective arthroplasty of the hip. *Acta Orthop Scand* 2004; 75: 30-33.
  - [30] Kleinert K, Werner C, Mamisch-Saupe N, Kalberer F, Dora C. Closed suction drainage with or without re-transfusion of filtered shed blood does not offer advantages in primary non-cemented total hip replacement using a direct anterior approach. *Arch Orthop Trauma Surg* 2012; 132: 131-136.
  - [31] Matsuda K, Nakamura S, Wakimoto N, Kobayashi M, Matsushita T. Drainage does not increase anemia after cementless total hip arthroplasty. *Clin Orthop Relat Res* 2007; 458: 101-105.
  - [32] Niskanen R, Korkala O, Haapala J, Kuokkanen H, Kaukonen JP, Salo S. Drainage is of no use in primary uncomplicated cemented hip and knee arthroplasty for osteoarthritis: a prospective randomized study. *J Arthroplasty* 2000; 15: 567-569.
  - [33] Snell S. On the suction-operation for cataract. *Br Med J* 1876; 1: 595.
  - [34] Sehat K, Evans R, Newman J. Hidden blood loss following hip and knee arthroplasty correct management of blood loss should take hidden loss into account. *J Bone Joint Surg* 2004; 86: 561-565.
  - [35] Sehat K, Evans R, Newman J. How much blood is really lost in total knee arthroplasty?: correct blood loss management should take hidden loss into account. *Knee* 2000; 7: 151-155.
  - [36] Gross JB. Estimating allowable blood loss: corrected for dilution. *Anesthesiology* 1983; 58: 277-280.