Systematic Review and Meta-Analysis

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Are closed suction drains necessary for primary total knee arthroplasty?

A systematic review and meta-analysis

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Abstract

Background: Placement of closed suction drains after total knee arthroplasty is an age-old practice; however, benefits and disadvantages of this procedure remain disputable in various studies.

Methods: We performed an electronic database search in Medline/PubMed, the Cochrane Library, and Embase to retrieve publications with respect to this issue and then screened reference lists of related articles manually to obtain any additional ones. Randomized controlled trials (RCTs) evaluating the use of closed suction drains after primary total knee arthroplasty were eligible for this study. Useful data were extracted to calculate the pooled risk ratios (RRs) or weighted mean differences (WMDs) as well as corresponding 95% confidence intervals (CIs) as summary estimates.

Results: Nineteen RCTs were included in the quantitative analysis. Compared with patients in the nondrainage group, those in the drainage group were significantly correlated with a decreased need of dressing change (RR = 0.31, 95% CI 0.12 to 0.79, P = .015) but an increased risk of homologous transfusion (RR = 1.38, 95% CI: 1.04–1.83) and longer time to regain straight-leg raising (WMD = 0.97 d, 95% CI: 0.48–1.46). Two groups showed no significant difference in total blood loss, hemoglobin drop, superficial wound infection, prosthetic joint infection, formation of deep vein thrombosis, duration of hospital stay, and range of movement.

Conclusions: Based on this analysis, the use of closed suction drains after total knee arthroplasty is probably not superior to no drains for most outcome measures and therefore surgeons may wish to reconsider the routine use of this empirical practice until there is further evidence.

Abbreviations: CI = confidence interval, CONSORT = Consolidated Standards of Reporting Trials, DVT = deep vein thrombosis, PRISMA = the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, RCT = randomized controlled trial, ROM = range of motion, RR = risk ratio, WMD = weighted mean difference.

Keywords: closed suction drains, meta-analysis, randomized controlled trial, total knee arthroplasty

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1. Introduction

Hematoma formation is a matter of concern after total knee arthroplasty. On the one hand, it was thought to provide a good medium for the colonization of bacteria and act as a risk factor of superficial wound infection and periprosthetic joint infection; one the other hand, increased tissue tension caused by a large hematoma might affect blood perfusion and joint mobility.[1,2] In order to evacuate blood trapped in the joint cavity, prevent the formation of hematoma and therefore reduce the incidence of abovementioned complications, an intraarticular closed suction drain is often installed at the end of total knee arthroplasty.[1] However, this age-old practice was questioned as multiple articles failed to demonstrate that fewer infections occurred owing to the use of drains; contrarily, some authors reported retrograde infection caused by bacteria migration through drain lumen.[3] Although lots of orthopedists still follow this practice empirically, debate over the benefits of closed suction drains has never stopped.[4–7] We performed a systematic review and meta-analysis with respect to this topic in 2011[8]; however, at that time, pooled analyses of several valuable outcome parameters were unavailable due to limited number of trials. Some high-quality studies were published in recent years and for the purpose of better illustrating this issue, an updated meta-analysis is requisite.

2. Method

We conducted this research according to the checklist of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[9] The database search, literature selection, methodological assessment, and data abstraction were performed by 2 investigators (QYZ and LL) independently and repeatedly. Disagreement was settled by consensus or arbitration of the third investigator (WS). Informed consent or ethics approval was not needed due to that data pooled in the quantitative analysis were extracted from published articles.

2.1. Database search and literature selection

We performed a computerized search for 3 electronic databases including PubMed/Medline, Embase, and the Cochrane Library using queries combined by following keywords: ("drain" OR "drainage") AND ("arthroplasty" OR "joint replacement"). No language or time limitations were imposed, and the last database search was conducted on June 14, 2017. Bibliographies of relevant articles were then hand checked to retrieve other additional articles of interest. Studies eligible for our meta-analysis had to meet the criteria listed below: study design, randomized controlled trial (RCT); population, candidates that require total knee arthroplasty; closed suction drains were adopted in the experimental group; and sufficient data were provided in regard to infection, blood loss, hemoglobin drop, transfusion, ecchymosis, deep vein thrombosis (DVT), range of motion, length of hospital stay, or other outcome estimates. After obviously unqualified and redundant publications were excluded by reading titles and abstracts, full texts of remainders were acquired and reviewed to ascertain their eligibility.

2.2. Data extraction and methodology quality assessment

For eligible studies, following information was extracted and imported to a predesigned Excel table: authors, published year, inclusion period, study design, demographic data of participants, related disorders, time to remove drains, criteria for homologous transfusion, length of follow-up, and methodological information. Methodological quality was assessed by using the Consolidated Standards of Reporting Trials (CONSORT) checklist.[10] This tool contains 22 items and a higher score represents better quality.

2.3. Statistical analysis

Heterogeneity across studies was quantitatively assessed by using I^2 statistic and an I^2 of <50% indicated a statistically nonsignificant heterogeneity. By using a random effect model, we calculated the pooled risk ratio (RR) and corresponding 95% confidence intervals (CIs) for dichotomous data; meanwhile, weighted mean difference (WMD) as well as associated 95% CIs was applied to compare continuous data. All statistical processes were performed by using STATA, Version 12.0 (StataCorp, College Station, TX).

3. Results

The database search and study selection processes are depicted in Fig. 1. Characteristics of included trials and enrolled subjects are presented in Tables 1 and 2.

Eventually, 19 RCTs[11–29] were considered eligible for this meta-analysis, 17[11–18,20,21,23–29] of which were published in English, 1[22] in French, and 1[19] in Chinese. Fourteen[11,13,17–22,24–29] trials reported the random method, of which 11[11,13,18–22,24–26,28] applied sealed envelope, 1[29] used randomization chart, 1[17] decided the grouping by tossing a coin, and 1[27] was a quasi-randomized trial. As to the inclusion criteria, 14[13,16–25,27–29] RCTs only enrolled patients receiving unilateral arthroplasty; 3[14,15,26] RCTs adopted self-control method, recruited patients receiving bilateral arthroplasty, and administrated one side with closed suction drain and another side without; 1[12] RCTs which did not apply self-control also enrolled only bilateral patients and 1[11] RCTs recruited bilateral and unilateral patients simultaneously. All studies investigated primary total knee arthroplasty (TKA) and adopted cemented endoprostheses.

3.1. Infection

Eight[11,12,14,16,21,23,28,29] RCTs provided detailed data accessible to obtain RR and corresponding 95% CIs of superficial wound infection between 2 groups and 5[12,17,19,20,26] RCTs reported periprosthetic joint infection. There was no significant heterogeneity across included trials ($I^2=0$ in both subgroup analyses). The pooled outcome estimates of these studies suggested that the use of closed suction drains did not significantly influence infection rate, either superficial wound infection (RR=1.10, 95% CI: 0.38–3.19, $P=.861$) or periprosthetic joint infection (RR=0.51, 95% CI: 0.13–1.98, $P=.392$) (Fig. 2).

3.2. Total blood loss, hemoglobin drop, and transfusion

Postoperative calculating blood loss contains 2 parts, namely, visible blood loss and hidden blood loss. Four[12,13,16,21] RCTs provided means and standard deviations of total blood loss in the drainage group and the nondrainage group, in which 3[12,13,16] trials assessed the exact blood loss by using Gross's formula and 1[21] did not depicted the method to calculate total blood loss. The pooled result indicated a trend toward more total blood loss in the drainage group compared with the nondrainage group but the difference was not statistically significant (WMD=99.60 mL, 95% CI: −15.91 to 215.11, $P=.091$; P for heterogeneity <.01, $I^2=87.4\%$) (Fig. 3).

Two[13,19] RCTs provided sufficient data accessible to calculate WMD and associated 95% CIs of hemoglobin drop between 2 groups. The summary estimate suggested that there was a trend toward more hemoglobin drop in the drainage group compared with the nondrainage group but the difference was not statistically significant, either (WMD=−1.88 g, 95% CI: −3.82 to 0.06, $P=.057$; P for heterogeneity=.808, $I^2=0\%$) (Fig. 3).

Ten[12,13,16,17,19–21,24,28,29] RCTs provided adequate data to calculate RR and associated 95% CIs of homologous transfusion rate between the drainage and the nondrainage groups. In this subgroup, the use of closed suction drains was correlated with a statistically increased rate of homologous transfusion (RR=1.38, 95% CI: 1.04–1.83, $P=.026$; P for heterogeneity=.026, $I^2=52.3\%$) (Fig. 4). The significant heterogeneity across studies may result from the diverse standard to initiate transfusion.

3.3. Straight-leg raising and range of movement (ROM)

In 2[13,16] RCTs, investigators assessed the difference of time to regain straight-leg raising in the drainage group and nondrainage group. The WMD was 0.97 d (95% CI: 0.48–1.46, $P<.001$;

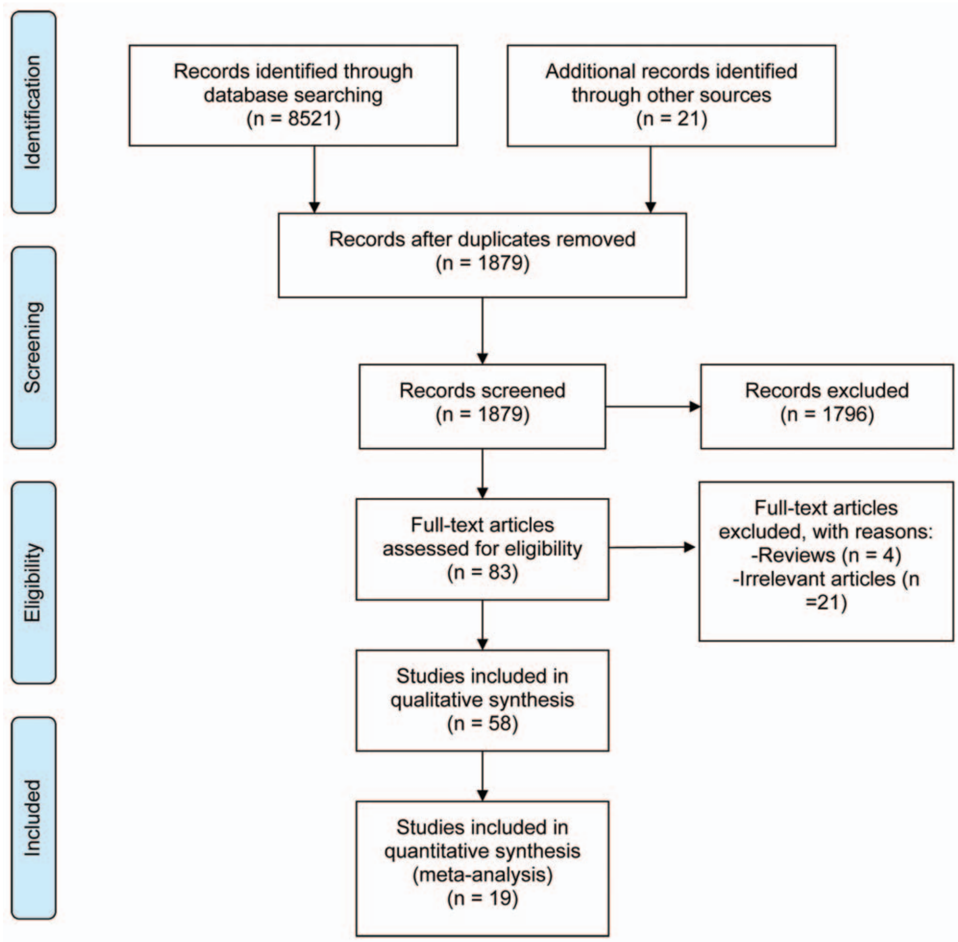

Figure 1. A flow chart summarizing the selection process of included RCTs for this meta-analysis.

Table 1

Characteristics of included studies.

Refs.	Year	Country	Inclusion period	criteria for homologous transfusion	Time to remove drains	Follow-up	CONSORT score
Ritter et al[29]	1994	America	NR	Hb < 90 g/L	Postoperative 24 h	NR	19
Ovadia et al[28]	1997	Israel	June 1994–December 1994	Hb < 8 g% or 10 g% with clinical signs of hypovolemia	NR	Discharge	18
Holt et al[27]	1997	America	NR	Symptomatic or Hb < 7 g/dL	Postoperative day 2	4 wk after discharge	16
Kim et al[26]	1998	South Korea	NR	NR	Postoperative 24 h	1 y after surgery	19
Crevoisier et al[25]	1998	Switzerland	NR	NR	Postoperative 48 h	discharge	20
Adalberth et al[24]	1998	Sweden	NR	Hb < 90 g/L or a decrease of Hb > 30% from preoperative value	Postoperative 24 h	4 mo	15
Niskanen et al[23]	2000	Finland	NR	NR	Postoperative 24 h	2 mo	17
Jenny et al[21]	2001	France	NR	The hematocrit level < 30% with patient's complaints	Postoperative day 2	7th–14th day after operation	18
Mengal et al[22]	2001	Belgium	NR	NR	NR	NR	17
Esler et al[20]	2003	England	NR	Hb < 10 g/dL	Postoperative 48 h	5 y	19
Tao et al[19]	2006	China	December 2002–August 2003	Hb < 90 g/L	Postoperative 48 h	2.5 y	20
Omonbude et al[18]	2010	England	May 2006–March 2007	NR	Postoperative 24 h	6 wk	20
de Andrade et al[17]	2010	Brazil	October 2007–April 2009	Presence of clinical signs and symptoms that could be explained as anemia	Postoperative 24 h	over 6 mo	19
Li Cao et al[16]	2011	China	February 2006–February 2007	Hb < 90 g/L	NR	1 y after surgery	18
Fan et al[15]	2013	China	October 2007–September 2009	NR	postoperative 24–48 h	1 y after surgery	18
Jhurani et al[12]	2016	India	April 2013–December 2014	Hb < 8 g/dL	postoperative 24 h	6 mo	18
Wang et al[13]	2016	China	January 2015–September 2015	Hb < 70 g/L or 70–100 g/L with symptoms	NR	3 mo	20
Sharma et al[11]	2016	India	May 2014–May 2015	NR	postoperative 24 h	1 y after surgery	20
Watanabe et al[14]	2016	Japan	December 2007–August 2008	NR	postoperative 24 h	5.5 y	19

Hb = hemoglobin, NR = not reported.

Table 2

Demographic information of subjects.

	No. of knees		Mean age, y		Male/female		
Refs.	**DG**	**NDG**	**DG**	**NDG**	**DG**	**NDG**	**Disorders**
Ritter et al[29]	137	138	NR	NR	NR	NR	NR
Ovadia et al[28]	32	26	73.7 ± 5.5	69.7 ± 6.5	7/25	6/20	OA/RA/ON
Holt et al[27]	69	67	70 (46–93)	69 (46–81)	24/45	20/48	NR
Kim et al[26]	69	69	64 (37–80)	64 (37–80)	7/62	7/62	OA/RA
Crevoisier et al[25]	16	16	NR	NR	NR	NR	NR
Adalberth et al[24]	25	24	72 (69–75)	70 (67–74)	9/16	11/13	NR
Niskanen et al[23]	20	19	70 (56–82)	71 (54–89)	4/16	5/14	NR
Jenny et al[21]	30	30	NR	NR	NR	NR	NR
Mengal et al[22]	52	52	NR	NR	NR	NR	NR
Esler et al[20]	50	50	73.1 (50–86)	72.1 (50–88)	23/27	22/28	OA/RA
Tao et al[19]	50	50	72 ± 5	71 ± 5	18/32	15/35	OA/RA
Omonbude et al[18]	40	38	71.1 (52–83)	68.4 (43–88)	20/20	23/15	OA
de Andrade et al[17]	27	15	69.00 ± 9.31	69.93 ± 7.11	NR	NR	NR
Cao et al[16]	50	50	64.9 ± 8.7	61.9 ± 13.5	14/36	10/40	OA/RA
Fan et al[15]	40	40	66.5 (49–75)	66.5 (49–75)	NR	NR	OA
Jhurani et al[12]	115	115	64.0 ± 7.8	65.0 ± 8.7	26/89	36/79	OA/RA
Wang et al[13]	40	40	66.9 ± 8.6	66.8 ± 10.1	8/32	9/31	NR
Sharma et al[11]	61	59	72.03 ± 6.68	71.38 ± 7.02	NR	NR	OA
Watanabe et al[14]	22	22	74 ± 7	74 ± 7	18/4	18/4	OA/RA

DG = the drainage group, NDG = the nondrainage group, NR = not reported, OA = osteoarthritis, ON = osteonecrosis, RA = rheumatoid arthritis.

P for heterogeneity = .701, $I^2 = 0\%$) (Fig. 5), which indicated that about one more day was needed to restore straight-leg raising for patients in the drainage group compared with those in the nondrainage group.

Range of movement in 2 groups was available to be integrated and compared at postoperative day 1 (POD 7), POD 14, and long-term which was defined as more than 3 months after arthroplasty. There were 6,[14–17,19,21] 4,[15–17,19] and 6[13–17,19]

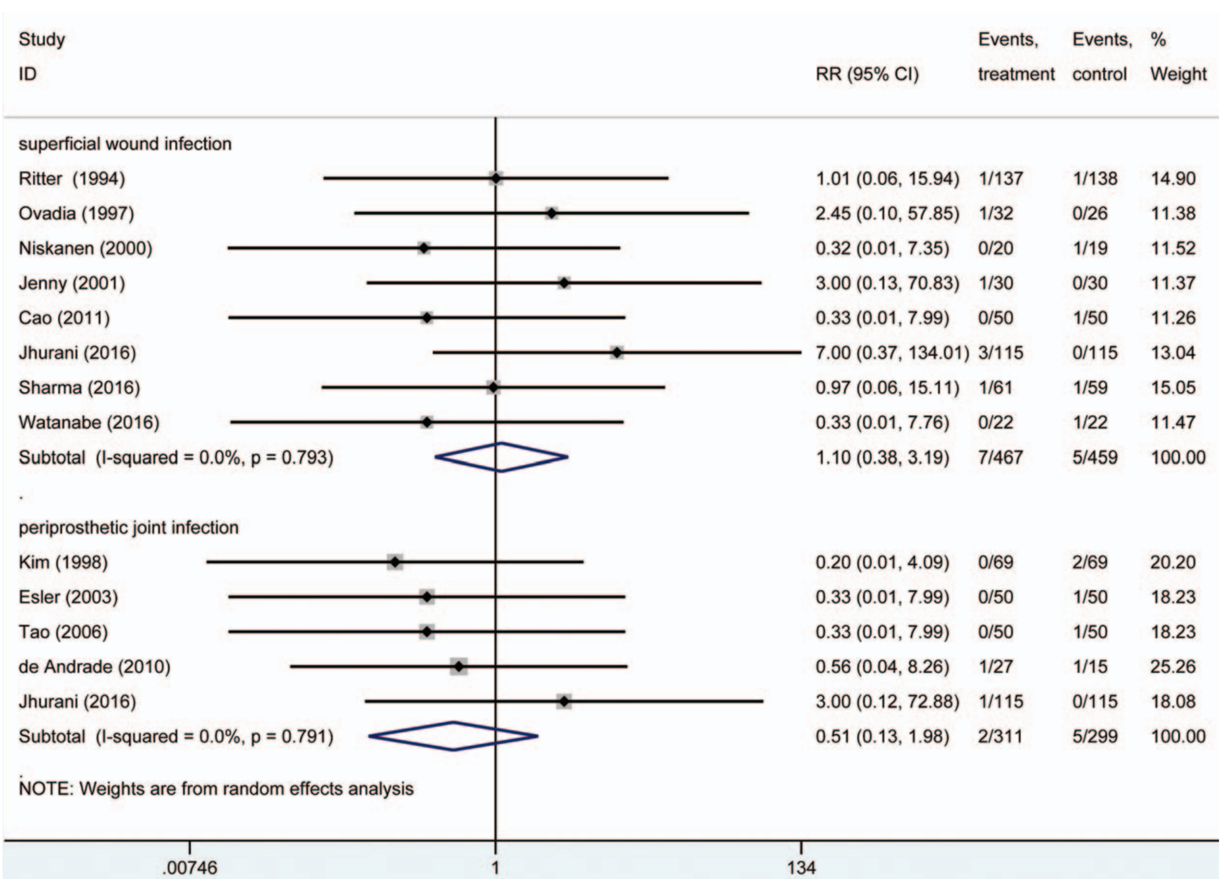

Figure 2. Incidence of postoperative infections between the drainage group and the nondrainage group.

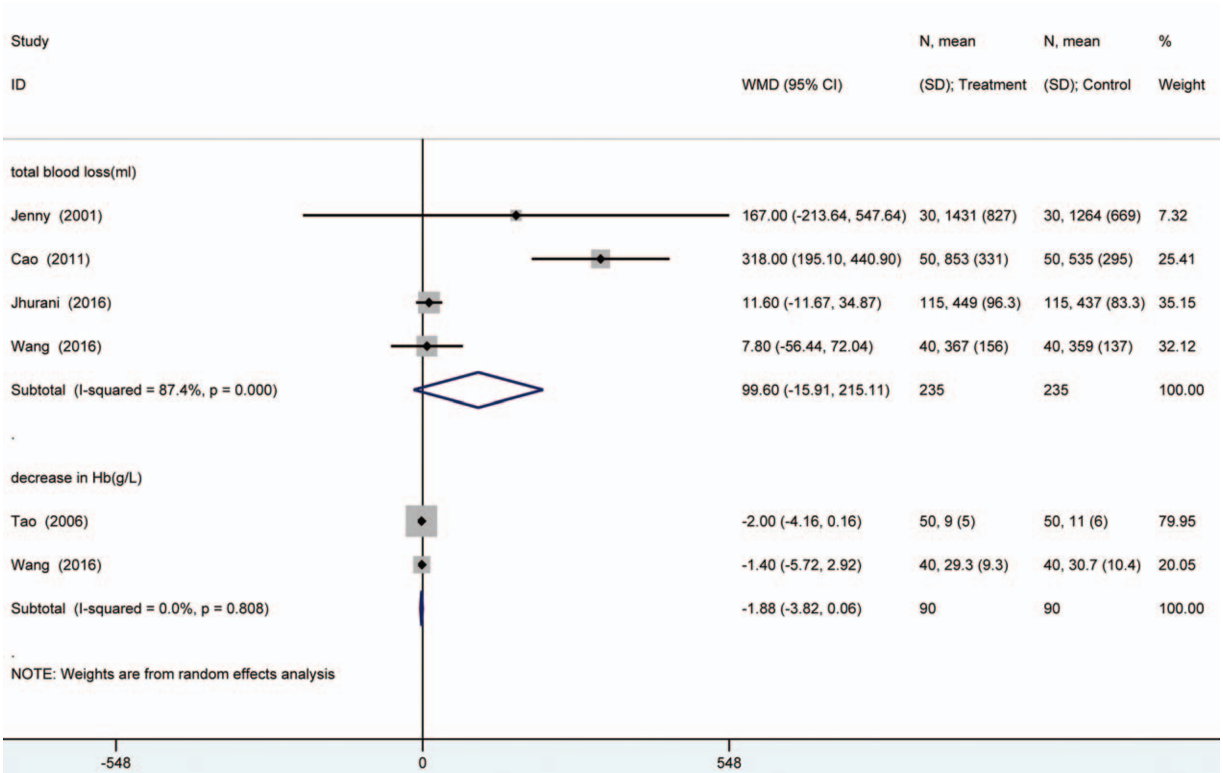

Figure 3. Postoperative total blood loss and hemoglobin drop between the drainage group and the nondrainage group.

RCTs provided adequate data to calculate WMDs and associated 95% CIs of ROM between 2 groups at 3 time points, respectively, which all did not make statistically significant difference (WMD = 1.12°, 95% CI: −1.92 to 4.16, P = .470; P for heterogeneity = .223, I^2 = 28.2%; WMD = 1.58°, 95% CI: −3.29 to 6.45, P = .525; P for heterogeneity = .099, I^2 = 52.1%; WMD = −0.31°, 95% CI: −0.10 to 1.55, P = .229; P for heterogeneity = .890, I^2 = 0%, respectively) (Fig. 6).

3.4. Length of hospital stay, dressing reinforcement, and other complications

Six[11–13,17,19,28] studies provided enough data to assess the length of hospitalization in 2 groups and no statistically significant difference was found (WMD = 0.26 d, 95% CI: −0.21 to 0.73; P = .279; P for heterogeneity = .001, I^2 = 76.0%) (Fig. 5).

Five[11,20,23,26,27] RCTs provided adequate data to calculate RR and corresponding 95% CIs of dressing reinforcement between the drainage and the nondrainage groups. In this subgroup, use of closed suction drains was associated with a decreased risk of dressing change (RR = 0.31, 95% CI: 0.12–0.79, P = .015; P for heterogeneity = .002, I^2 = 77.0%) (Fig. 4).

Other complications, for instance, ecchymosis, DVT, and dehiscence were also analyzed in this study. There were 5,[13,19,20,26,27] 4,[15,22,24,27] and 3[17,25,28] RCTs provided adequate data to calculate RR and associated 95% CIs of ecchymosis, DVT, and dehiscence respectively between the drainage and the nondrainage groups. Statistical differences were not significant for all 3 outcome estimates (RR = 0.61, 95% CI: 0.36–1.03, P = .063 for ecchymosis; RR = 1.30, 95% CI: 0.53–3.22, P = .567 for DVT; and RR = 1.25, 95% CI: 0.13–11.59, P = .846 for dehiscence, respectively) (Fig. 4).

4. Discussion

Although placing closed suction drains after total knee arthroplasty is still a routine practice in the clinical setting, many orthopedists questions its value. The proposed benefits of drains include lower incidences of infection and wound complications, and possible shortcoming is more total blood loss. The former meta-analysis we performed focusing on this topic revealed several differences of outcome parameters between patients with and without closed suction drains.[8] However, due to the limited number of trials, some important indicators, such as total blood loss, hemoglobin drop, infection rate, range of movement, and length of hospital stay, were unavailable to be pooled or analyzed based on subgroups, which was specially emphasized in that article. Therefore, we conducted this updated systematic review and meta-analysis to further assess whether the application of closed suction drainage justified in patients undergoing total knee arthroplasty.

Infection after arthroplasty would bring catastrophic consequences and reducing the infection rate is the prime consideration for the application of closed suction drains. However, in the light of current evidence, no statistically significant correlation between drainage tube placement and infection (either superficial one or periprosthetic joint one) reduction could be detected. In a prospective investigation conducted by Willemen et al,[30] 41 patients receiving TKAs were randomly assigned to 2 groups according to the time of removing drains. Bacteria cultures of all drain tips cut off at postoperative

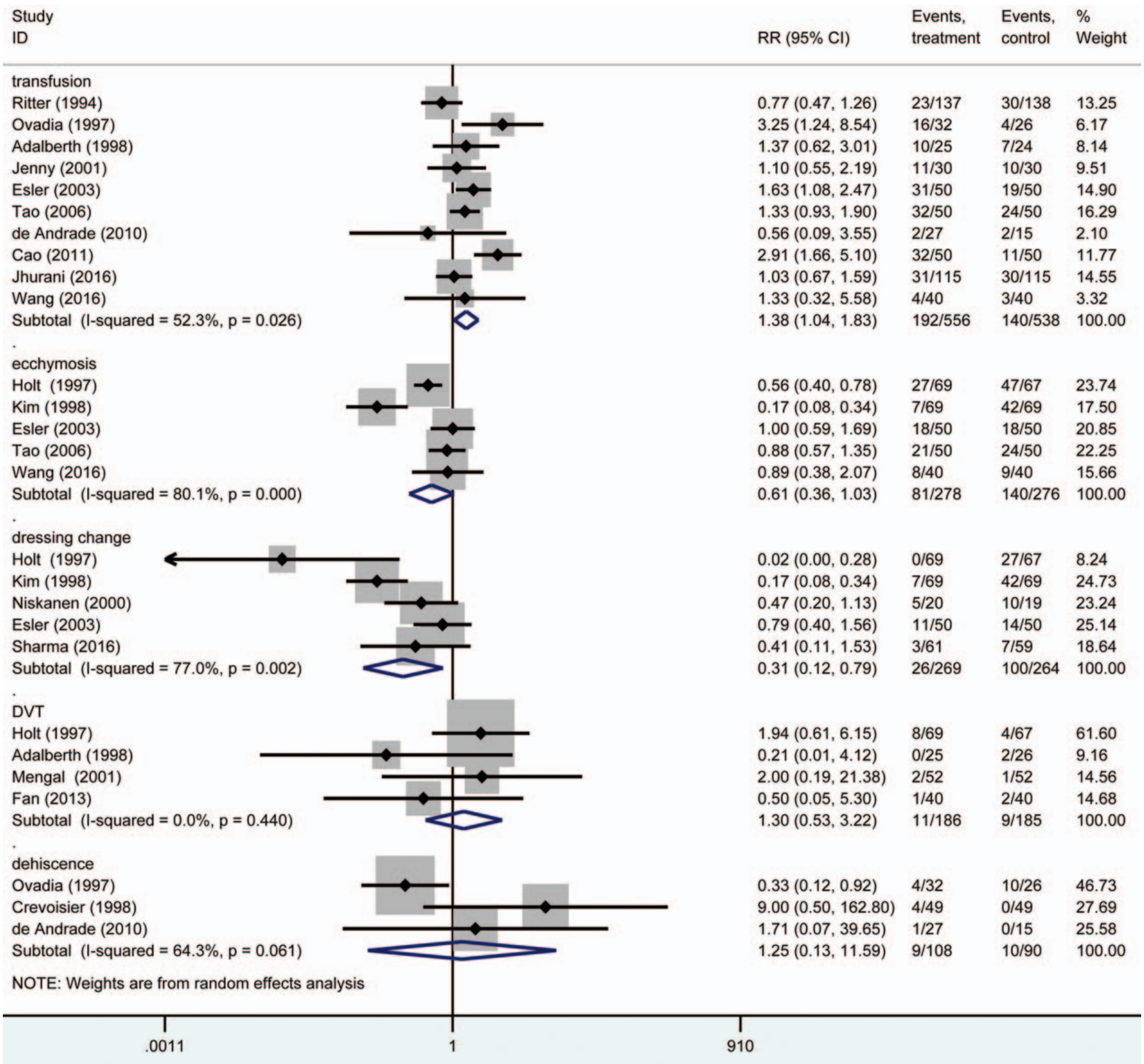

Figure 4. Incidence of postoperative homologous transfusion, ecchymosis, dressing change, DVT, and dehiscence between the drainage group and the nondrainage group.

24 hours yielded negative results and surprisingly, *Staphylococci* were isolated from 5 of 21 drain tips indwelling for 48 hours after operation. These results indicated that closed suction drains did act as a source of retrograde infection and the risk increased with the extension of indwelling time.

Homologous blood transfusion may generate issues like hematogenous infections (i.e., hepatitis B, hepatitis C, and acquired immune deficiency syndrome), hemolytic reaction, anaphylactic reaction, and cardiopulmonary diseases. Some authors proposed that due to the lack of "self-tamponade" effect, the use of drains might be associated with an elevated amount of total blood loss; meanwhile, blood perfusion around the wound reactively increases within hours after operation and therefore the drain tubes were advised to be clamped for about 4 to 6 hours.[31,32] Although we did not observe a significant difference in calculating blood loss or hemoglobin drop between the drainage group and the nondrainage group, elevated rate of postoperative homologous blood transfusion did correlate with the insertion of closed suction drains. The plausible reason is the heterogeneous and sometimes subjective criteria for transfusion. These results were consistent with those of a noncontrolled trial conducted by Mardian et al.[33]

A drainage tube would obstruct physiotherapy in the early postoperative period[20]; at the same time, theoretically for patients without drains, hematoma formation, and organization in joint cavities may hinder early exercise, generate loads of scars, and reduce ROM. In the short run, closed suction drainage appears to interfere with the ability to regain straight-leg raising; however, similar ROM was obtained in both groups at 3 time points after operation. One possible explanation is that the early and arduous exercise in patients without drains help to prevent the scar adhesion and therefore maintain a satisfactory ROM.

Ecchymosis and dressing changing reflect the amount of fluid oozing out of the joint cavity to soft tissue or surgical dressing. As the blood and other fluids were evacuated, less dressing

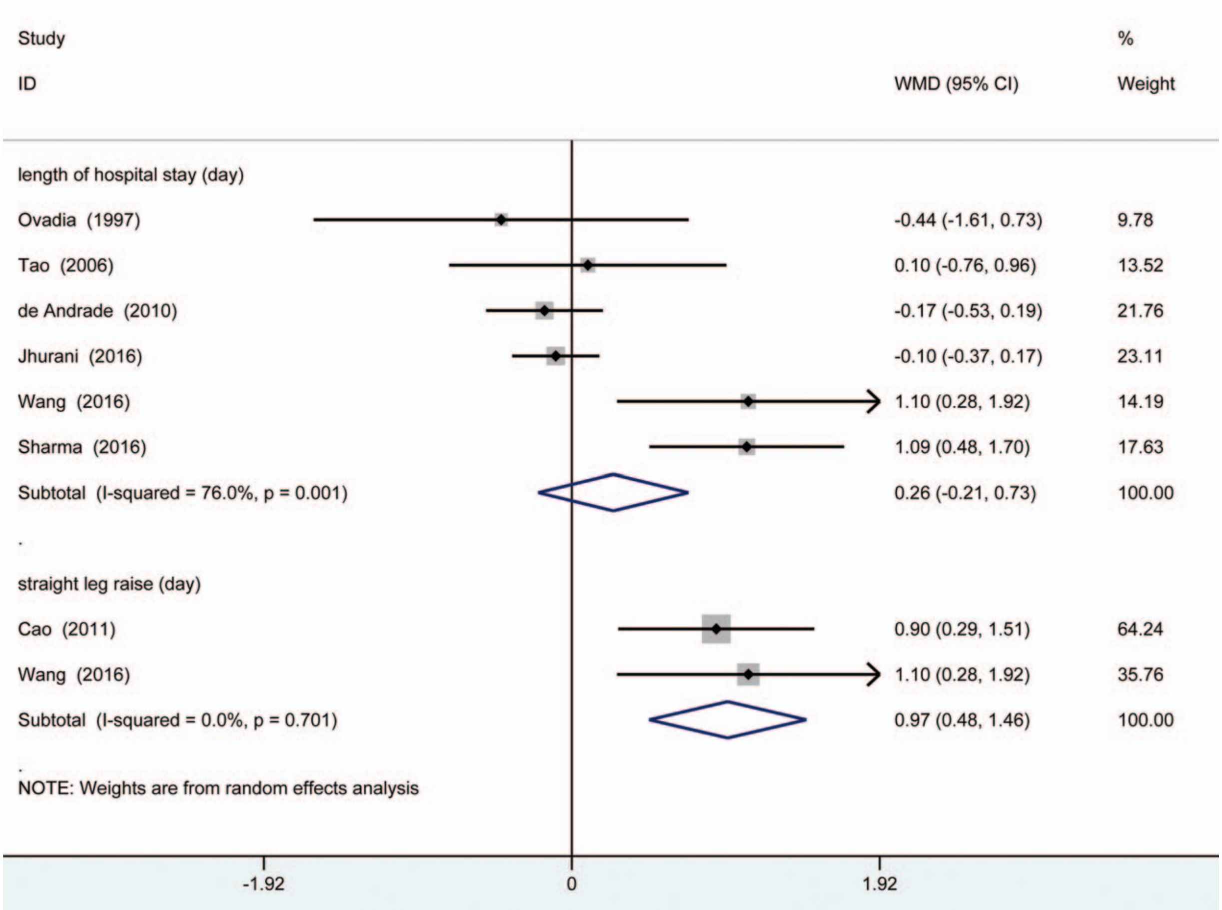

Figure 5. Duration of hospital stay and time to restore straight-leg raising between the drainage group and the nondrainage group.

reinforcement in the short term after the operation was reported in the drainage group; meanwhile, the extent of ecchymosis of drainage group was greater than that in the nondrainage group.[26,27] However, short-term complications such as DVT and dehiscence appear to be irrelevant to the application of closed suction drains. Length of hospital stay, which comprehensively represents the occurrence of postoperative events, is also similar in 2 groups. In Watanabe et al's study[14] with a mean follow-up of 5.5 years, no differences in radiographic manifestations such as radiolucent lines around endoprostheses between those with and without drains was observed.

Results of meta-analysis should be interpreted cautiously. Although homologous transfusion rates between 2 groups showed a statistically significant difference, it was noted that lower limit of the 95% CIs of this summary estimate was close to invalid line, which represented a limited clinical value of this result. Meanwhile, closed suction drains do result in approximately one additional day to regain active straight-leg raising and one-third the need to conduct dressing change compared with those without drains. Except for these clinical parameters aforementioned, use of closed suction drains brings issues of nonnegligible material cost and labor burden. In Yin et al's prospective studies,[2] conservative estimates showed that approximately 31.87 dollars per patient were needed for drain use. Meanwhile, placement of closed suction drains extends operation time and as drains were removed at postoperative 24 hours or longer, it would increase the workloads of orthopedists and nurses.

Several limitations existed in this investigation. Firstly, number of analyzed studies in each subgroup analyses were small. Secondly, heterogeneity across studies could not be fully expounded, which indicated existence of unnoticed biased factors such as surgical operation, mental state, kinds of prosthesis, and so on. Last but not least, some demographic and methodological data were not reported in original studies. In spite of these concerns, limited value of closed suction drains in primary total knee arthroplasty was found in current meta-analysis.

5. Conclusions

Our investigations revealed that the placing closed suction drains after total knee arthroplasty proven to be ineffective for infection prevention, blood loss control, or functional recovery. Although drain usage could decrease the need for dressing reinforcement, it was also associated with an elevated rate of homologous transfusion and delayed time to regain the straight-leg raising. In conclusion, based on this analysis, the use of closed suction drains after total knee arthroplasty is probably not superior to no drains for most outcome measures and therefore surgeons may wish to reconsider the routine use of this empirical practice until there is further evidence.

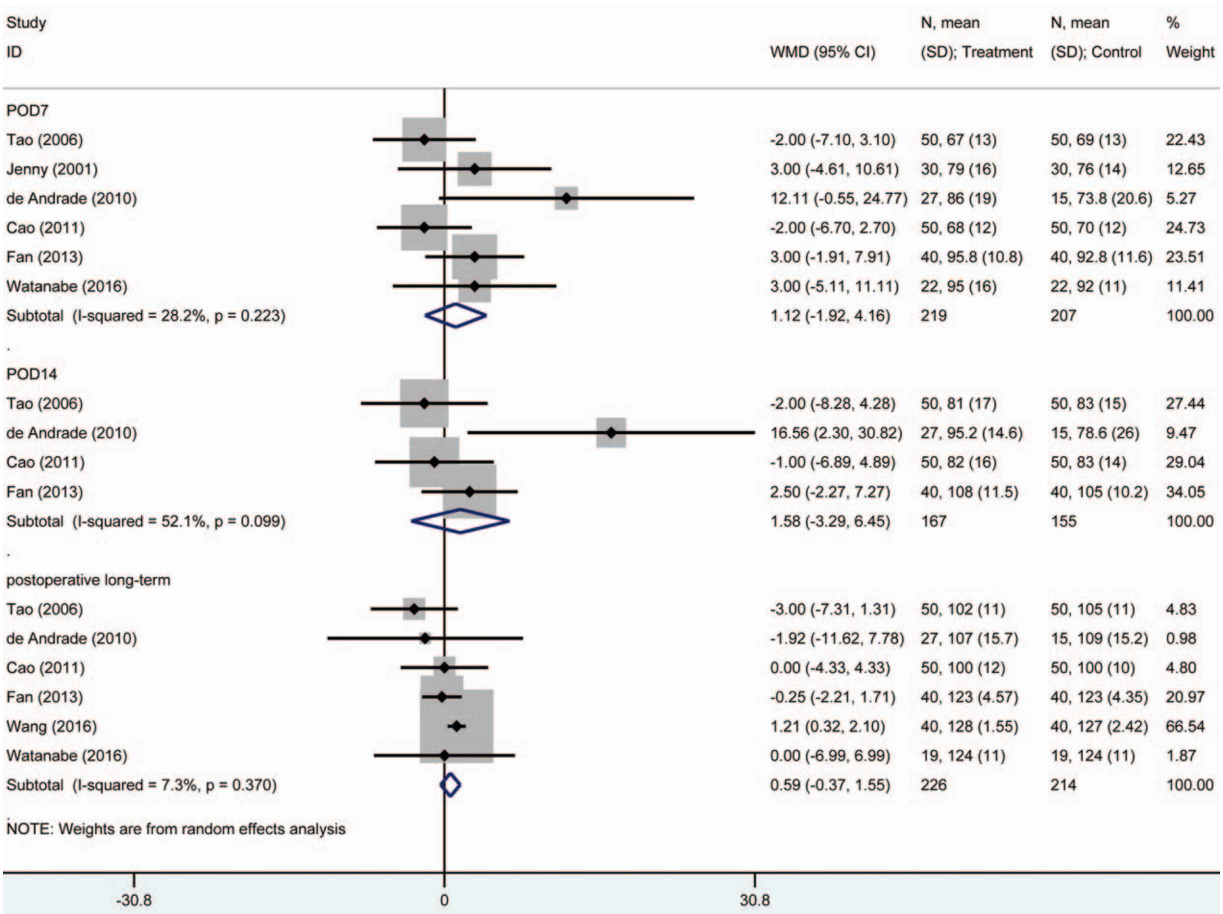

Figure 6. Postoperative range of movement between the drainage group and the nondrainage group.

Author contributions

Conceptualization: Wei Sun.
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Funding acquisition: Wei Sun.
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Validation: Wei Sun.
Writing – original draft: Qingyu Zhang, Lihua Liu.
Writing – review & editing: Fuqiang Gao, Qidong Zhang, Liming Cheng.

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