



Comparison of adductor canal block with local infiltration analgesia in primary total knee arthroplasty: A meta-analysis of randomized controlled trials



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ABSTRACT

Background: Currently, there remains a paucity of literature about the efficiency of adductor canal block (ACB) versus local infiltration analgesia (LIA) for pain management after total knee arthroplasty (TKA). The purpose of this study was to perform a relatively credible and overall assessment to compare the efficiency of ACB versus LIA for early postoperative pain treatment after TKA.

Methods: A comprehensive search of the published literature in PubMed, MEDLINE, Cochrane, EMBASE, and Web of Science databases was performed. Only randomized clinical trials (RCTs) or quasi-RCTs were included in this study. The primary outcome was pain score. Secondary outcome measures included opioid consumption, functional outcome (such as timed up and go test and distance walked), and length of stay.

Results: Eight RCTs with a total of 675 patients were included. No statistically significant difference was observed between the ACB and LIA groups in pain scores at 24 h or 48 h, total opioid consumption at 24 h or 48 h, and length of stay. However, the LIA group exhibited greater improvements in ambulation ability ($P = 0.03$) and distance walked ($P < 0.00001$).

Conclusions: Both treatments provide similar overall pain relief after TKA. LIA may achieve earlier ambulation compared with ACB. More high-quality RCTs are still required to make the final conclusion.

1. Introduction

Currently, total knee arthroplasty (TKA) has been widely used in treatment for the elderly patients with end-stage osteoarthritis [1]. However, due to the soft tissue injury and large amount of bone destruction involved, undesirable postoperative pain remains a challenge for both patients and surgeons after TKA [2]. Previous study [3] has shown that 23% of patients cite at home pain as “severe/extreme” after surgery, whereas 54% of the patients indicate “severe pain at least some of the time.” In addition, it has been suggested that severe pain can also interfere with the recovery process, which increases the risk of postoperative complications, including infection, joint loosening, and reflex sympathetic dystrophy [4].

At present, various techniques can be used to relieve postoperative pain, including epidural anesthesia, femoral nerve block (FNB), adductor canal block (ACB), and local infiltration analgesia (LIA). FNB is known as the gold standard to reduce opiate consumption and decrease postoperative pain scores in TKA [5,6]. Unfortunately, it tends to result in motor blockade of the quadriceps muscle and potentially delay

postoperative mobilization, as well as increase the risk of falls [7]. Recently, ACB has emerged as an alternative to FNB, with the advantage of sparing the motor nerve supply to most of the quadriceps muscle and may lead to a reduction in falls after surgery [8,9]. LIA is a surgeon-controlled analgesic technique that used to reduce the pain in the early postoperative period with no influence on quadriceps strength. It has been shown to have superior analgesic effects compared to placebo [10,11] and non-inferior compared to femoral nerve block [12]. LIA during TKA has thus been recommended for routine application considering effective pain relief and smoother rehabilitation.

However, limited randomized clinical trials (RCTs) have been conducted to compare the efficacy of ACB with that of LIA in patients undergoing TKA. Only 1 meta-analysis has synthesized available evidence to explore the efficacy between ACB vs LIA in reducing pain after TKA, which showed that LIA could significantly improve postoperative pain and opioid consumption when compared with ACB [13]. Since several RCTs have been recently published, we thus conduct an updated high-quality meta-analysis to investigate which analgesic provides better pain relief.

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2. Materials and methods

2.1. Selection of studies

A comprehensive search of the published literature in PubMed, MEDLINE, Cochrane, EMBASE, and Web of Science databases was performed based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [14]. The detailed search strategy was as follows: (total knee arthroplasty or total knee replacement or TKA or TKR) and (adductor canal block or saphenous nerve block or peripheral nerve block) and (local infiltration analgesia or periarticular anesthetic injection or periarticular infiltration) and (random or blind). All articles published up to May 10, 2019, were included, including articles published online. The reference lists of the included studies were also checked for additional studies that were not identified with the database search.

2.2. Inclusion and exclusion criteria

Study included in our meta-analysis had to meet all of the following inclusion criteria in the PICOS order: (1) population: patients who received unilateral primary TKA; (2) intervention: patients received ACB after TKA; (3) comparison intervention: patients received LIA after TKA; (4) outcome measures: at least one of the following outcome measures was reported: pain score, opioid consumption, functional outcome, and length of stay; (5) study design: RCTs or quasi-RCTs. Articles with no assessment of outcomes mentioned above or no direct comparison of ACB and LIA were not included into meta-analysis. Duplicate reports and conference abstracts were excluded. Case reports, biochemical trials, letters, and reviews were also eliminated.

2.3. Study selection

Articles were exported to EndNote, and duplicates removed. Two independent authors screened the titles and abstracts of potentially relevant studies to determine their eligibility based on the criteria. Disagreements were resolved through a discussion with a third review author.

2.4. Data extraction and analysis

A standard data extraction form was used independently by two reviewers to retrieve the relevant data from the articles. The extracted data included author, study design, sample size, publishing date, population, age, gender, type of interventions, dosages and type of anesthesia. The primary outcome was pain score. Secondary outcome measures included opioid consumption, functional outcome [such as timed up and go (TUG) test and distance walked], and length of stay. Data extraction was performed independently, and any conflict was resolved before final analysis. If the data were missing or could not be extracted directly, authors were contacted by email. Otherwise, we calculated them with the guideline of Cochrane Handbook for Systematic Reviews of Interventions 5.1.0. If necessary, we would abandon the extraction of incomplete data.

2.5. Quality assessment

The Cochrane risk of bias tool was used to evaluate the risk of bias of included RCTs by 2 independent reviewers [15]. The quality of RCTs was assessed by using following 7 items: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. Kappa values were used to measure the degree of agreement between the 2 reviewers and were rated as follows: fair, 0.40 to 0.59; good, 0.60 to 0.74; and excellent, 0.75 or more. Any controversy was resolved by discussing with a third author to reach a

final consensus.

2.6. Statistical analysis

The present study was performed by Review Manager Software (RevMan Version 5.3, The Cochrane Collaboration, Copenhagen, Denmark). Standardized mean differences (SMD) with a 95% confidence interval were assessed for continuous outcomes. $P < 0.05$ was set as the significance level. The heterogeneity was assessed by using the Q test and I^2 statistic. All outcomes were pooled on random-effect model. The Z test was used to assess the overall effect. A meta-analysis was conducted when 3 or more trials reported an outcome of interest. Subgroup analyses were planned by different follow-up periods. We also conducted the sensitivity analysis to evaluate whether any single study had the weight to skew on the overall estimate and data. Begg's funnel plot was used to assess publication bias. If publication bias exists, the Begg's funnel plot is asymmetric.

3. Results

3.1. Study selection, characteristics, and risk of bias

The search of the literature through different databases identified 312 articles. A total of 227 articles were evaluated after duplicates from each database were excluded. Of these, 61 articles were excluded by title and abstract. After reading the full text of all remaining articles in detail, 16 studies that did not meet the inclusion criteria were excluded. A total of 8 articles [16–23] met our eligibility criteria (Fig. 1). Briefly, 8 RCTs with a total of 675 patients were included. Six of the studies [16,18–21,23] assessed pain using the visual analog scale, whereas only 2 studies [17,22] reported pain using the numeric rating scale. A detailed description of all included studies can be found in Table 1.

Seven of 8 studies described the methods of randomization, but Gurava Reddy et al. failed to provide enough details about randomization [20]. Six of 8 studies used appropriate and feasible methods to describe concealment of allocation [16,17,19–22]. There was no blinding of the participants and personnel in all 8 studies. Blinding of outcome assessors was mentioned in all studies. The proportion of patients lost to follow-up was less than 20% in all studies, indicating low attrition bias. Sawhney et al. did not report results of all predefined measures, indicating high reporting bias [22]. No other bias was detected. A standardized assessment of the risk of bias in the 8 RCTs was summarized in Fig. 2A and B. The overall kappa value regarding the evaluation of risk of bias was 0.851, meaning an excellent degree of agreement between the two reviewers.

3.2. ACB versus LIA outcomes analysis

3.2.1. Pain scores

Six studies [16–18,21–23] evaluated pain score with rest at 24 h between 178 patients treated with ACB and 183 patients treated with LIA. No significant difference was found between ACB and LIA groups (SMD for ACB vs LIA group, -0.13 ; 95% CI, -0.54 to 0.29 ; $P = 0.55$) (Fig. 3).

Six studies [16–18,21–23] evaluated pain score with rest at 48 h between 178 patients treated with ACB and 183 patients treated with LIA. Similarly, no significant difference was found between ACB and LIA groups (SMD for ACB vs LIA group, -0.15 ; 95% CI, -0.43 to 0.12 ; $P = 0.28$) (Fig. 3).

A total of 8 studies [16–23] compared pain score with movement at 24 h between 330 patients treated with ACB and 333 patients treated with LIA. No significant difference was demonstrated between ACB and LIA groups (SMD for ACB vs LIA group, -0.07 ; 95% CI, -0.35 to 0.21 ; $P = 0.64$) (Fig. 3).

A total of 8 studies [16–23] compared pain score with movement at 48 h between 331 patients treated with ACB and 334 patients treated

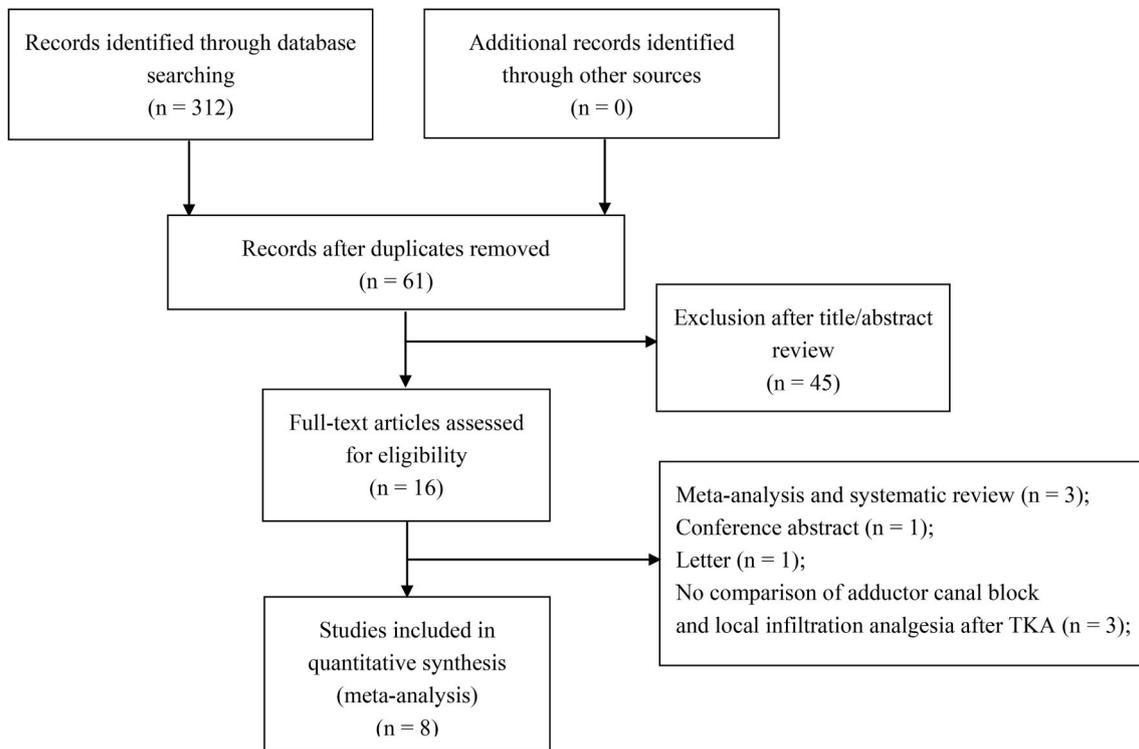


Fig. 1. PRISMA Flow diagram describing the selection process for relevant clinical trials used in this meta-analysis.

with LIA. No significant difference was demonstrated between ACB and LIA groups (SMD for ACB vs LIA group, -0.04 ; 95% CI, -0.32 to 0.23 ; $P = 0.77$) (Fig. 3).

3.2.2. Total opioid consumption

Only 4 studies [18,19,21,22] compared total opioid consumption at 24 h between 148 patients treated with ACB and 148 patients treated with LIA. No significant difference was found between the 2 methods (SMD for ACB vs LIA group, -0.20 ; 95% CI, -0.84 to 1.38 ; $P = 0.54$) (Fig. 4).

Seven studies [16–19,21–23] compared total opioid consumption at 48 h between 231 patients treated with ACB and 234 patients treated with LIA. No significant difference was demonstrated between ACB and LIA groups, but the total opioid consumption at 48 h tended to be in favor of ACB without reaching the threshold of significance (SMD for ACB vs LIA group, -0.37 ; 95% CI, -0.88 to 0.15 ; $P = 0.16$) (Fig. 4).

3.2.3. Functional outcome

Only 4 studies [16–18,21] compared TUG test at 24 h between 112 patients treated with ACB and 114 patients treated with LIA. Significant difference was found in the TUG test at 24 h in favor of LIA (SMD for ACB vs LIA group, 0.60 ; 95% CI, 0.04 to 1.15 ; $P = 0.03$) (Fig. 5A).

Only 3 studies [17,19,22] compared distance walked at 24 h between 123 patients treated with ACB and 126 patients treated with LIA. Similarly, significant difference was found in the distance walked at 24 h in favor of LIA (SMD for ACB vs LIA group, -0.69 ; 95% CI, -0.94 to -0.43 ; $P < 0.00001$) (Fig. 5B).

3.2.4. Length of stay

Five studies [17–19,21,23] evaluated length of stay between 146 patients treated with ACB and 145 patients treated with LIA. No significant difference was found between ACB and LIA groups (SMD for ACB vs LIA group, 0.20 ; 95% CI, -0.44 to 0.85 ; $P = 0.54$) (Fig. 6).

3.3. Quality of evidence

The GRADE system was used to evaluate the quality of outcomes in this study. The overall evidence for outcomes was moderate. The details of the results are summarized in Table 2.

3.4. Sensitivity analysis and publication bias

Owing to the significant heterogeneity in pain score with rest at 24 h ($I^2 = 73\%$), pain score with movement at 24 h ($I^2 = 67\%$) and 48 h ($I^2 = 66\%$), total opioid consumption at 24 h ($I^2 = 86\%$) and 48 h ($I^2 = 86\%$), and length of stay ($I^2 = 86\%$), the sensitivity analysis was performed in our meta-analysis to investigate the source of heterogeneity. Sensitivity analysis was performed by excluding one trial at a time and recalculating the pooled SMD for the remaining trials, which showed that none of the studies affected the most of results. However, in terms of length of stay, the I^2 value still exceeded 40% no matter which article was excluded, indicating an unstable result. The funnel plots of pain scores and total opioid consumption were symmetrical, indicating a low risk of publication bias. However, publication bias in our meta-analysis could not be totally excluded as only English articles were included into analysis (Fig. 7A and Fig. 7B).

4. Discussion

This meta-analysis was performed to investigate whether ACB is a better analgesic than LIA in terms of pain relief and functional recovery. The pooled results showed that ACB was as effective to LIA in terms of pain score at rest or movement, opioid consumption and length of stay. However, during the first 24 h, we found that LIA presented better results in the walking test than did the ACB group. The level of evidence, which was undermined by heterogeneity and study design limitations, was moderate or low, indicating that the degree of benefit must be studied although the benefit is conclusive.

The primary outcome evaluated in the present study was the pain score at different periods. Most of the included studies used the visual

Table 1
Characteristics of the included studies.

Study	Study Design	Sample size (ACB/LIA)	Anesthesia	Composition of ACB	Composition of LIA	Follow-Up	Outcome Measures
Cicekci 2019	RCT	39/40	Spinal anesthesia	Levobupivacaine 20 ml of 0.25%; Ropivacaine 15 ml of 0.5%;	Levobupivacaine 0.125 mg; Bupivacaine 50 ml of 0.25%;	2 days	VAS/Opioioid/TUG test
Grosso 2018	RCT	53/51	Spinal anesthesia			4 days	VAS/Opioioid/LOS/distance walked
Gurava Reddy 2018	RCT	100/100	Spinal anesthesia	Ropivacaine 20 ml of 0.75%;	Ropivacaine 30 ml of 0.2%, ketorolac 40 mg, adrenaline 0.5 ml, morphine sulfate 4 mg;	2 days	VAS
Kampitak 2018	RCT	29/28	Spinal anesthesia	Levobupivacaine 20 ml of 0.5%;	Levobupivacaine 20 ml of 0.5%, morphine 5 mg, adrenaline 0.3 ml, isotonic sodium chloride solution 40 ml;	3 days	VAS/Opioioid/LOS/TUG test
Tong 2018	RCT	20/20	Spinal anesthesia	Ropivacaine 30 ml of 0.5%;	Ropivacaine 150 mg, ketorolac 30 mg, morphine 10 mg, adrenaline 0.2 mg;	2 days	VAS/Opioioid/LOS/TUG test
Zhou 2018	RCT	20/20	General anesthesia	Ropivacaine 30 ml of 0.375%, epinephrine 5 µg/ml;	Ropivacaine 200 mg, epinephrine 0.5 mg;	2 days	VAS/Opioioid/LOS
Li 2017	RCT	24/26	General anesthesia	Ropivacaine 20 ml of 0.5%, adrenaline 0.1 mg;	Ropivacaine 70 ml of 0.375%, adrenaline 0.2 mg;	3 days	NRS/Opioioid/LOS/TUG test/ distance walked
Sawhney 2016	RCT	51/54	Spinal anesthesia	Ropivacaine 30 ml of 0.5%;	Ropivacaine 300 mg, morphine 10 mg, ketorolac 30 mg;	2 months	NRS/Opioioid/distance walked

RCT, randomized clinical trial; ACB, adductor canal block; LIA, local infiltration analgesia; NRS, numeric rating scale; VAS, visual analog scale, TUG (timed up and go).

analog scale except for the studies by Sawhney et al. [22], and Li et al. [17] which assessed pain levels by using the numeric pain rating scale. The pooled data indicated that the ACB group had a similar pain level at 24 h and 48 h after surgery than did the LIA group, regardless of whether the patient was at rest or moving. Total opioid consumption was also considered a reasonable indicator for assessing the analgesic effect. Our meta-analysis also indicated that the 2 groups consumed a similar amount of opioids at 24 h and 48 h post-operatively, which indirectly verified the aforementioned comparable outcomes of pain scores at the same time point between the ACB and LIA. A retrospective cohort study conducted by Gwam et al. [24] indicated no statistically significant difference in VAS scores and total opioid consumption between the 2 groups, which was consistent with our analysis.

Daily mobilization distance and TUG test were used to evaluate the capacity for activity. The TUG test was used to evaluate ambulation by measuring the time it took the patient to stand up from a chair, walk a distance of 3 m without any support, and return to the chair. The results of our meta-analysis showed that the ambulation ability of the LIA group was better than that of the ACB group. The pooled result also revealed that patients in the LIA group could walk longer distances than those in the ACB group in an ambulation distance test at 24 h post-operatively. The better functional outcomes indicated that ACB may reduce the strength of the related muscle and delay the post-operative mobilization. These results can be explained by the blocking of the saphenous nerve in the adductor canal through use of ropivacaine or bupivacaine over the first 24 h after the operation. A possible attenuating effect on quadriceps muscle strength from ACB may also reduce the knee ROM. However, due to limited data, we could not conduct a meta-analysis.

The length of hospital stay was associated with postoperative pain. As previous results revealed that the 2 groups had comparable pain scores, the length of stay was forecasted to be similar as well. This prediction was then confirmed by our meta-analysis as no statistical difference was found after pooling the results. However, the medical expense during hospitalization may differ between the 2 groups. Grosso et al. [19] showed that the provider fees associated with an ultrasound-guided ACB were \$1,740 (actual Medicare payment of; \$250) compared with < \$20 for the bupivacaine for LIA at their institution. From this perspective, LIA is a more cost-effective alternative to ACB for pain management.

Numerous meta-analyses have been published comparing the pain management of LIA, ACB and FNB in TKA. In a meta-analysis that included 10 RCTs, Zhang et al. [25] reported that patients who underwent LIA had improved knee society score and range of motion compared with those who received FNB alone, with no difference in pain relief, opioid consumption, and length of hospital stay. Kuang et al. [26] included 4 RCTs and 3 non-RCTs to compare FNB alone with ACB alone and found that the ambulation ability of the ACB was better than that of the FNB, with no significant differences in mean pain level, opioid use, or length of hospital stay, reporting that ACB has the potential to replace FNB as the gold standard for pain management in TKA patients. Our study shows that LIA is not inferior compared to ACB in pain relief, opioid consumption, and length of hospital stay while providing better ambulation ability.

The findings from our meta-analysis are not in line with findings from a previous meta-analysis [13]. These differences result from limited studies included in their analysis or inappropriate statistical method. The authors concluded that LIA could significantly improve postoperative pain and opioid consumption when compared with ACB. In the method section, the author emphasized that random-effect model was used for analysis if heterogeneity in the data is high. However, they still used the fixed-effect model to analyze the results, although all outcomes showed high heterogeneity, with I^2 ranged from 64% to 92%. In addition, functional outcomes and length of stay were not studied in their analysis due to limited data.

The current investigation should be interpreted in light of its

A

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
RCT Cicekci 2019	+	+	-	+	+	+	+
RCT Grosso 2018	+	+	-	+	+	+	+
RCT Gurava Reddy 2018	?	+	-	+	+	+	+
RCT Kampitak 2018	+	+	-	+	+	+	+
RCT Li 2017	+	+	-	+	+	+	+
RCT Sawhney 2016	+	+	-	+	+	-	+
RCT Tong 2018	+	?	-	+	+	+	+
RCT Zhou 2018	+	-	-	+	+	+	+

B

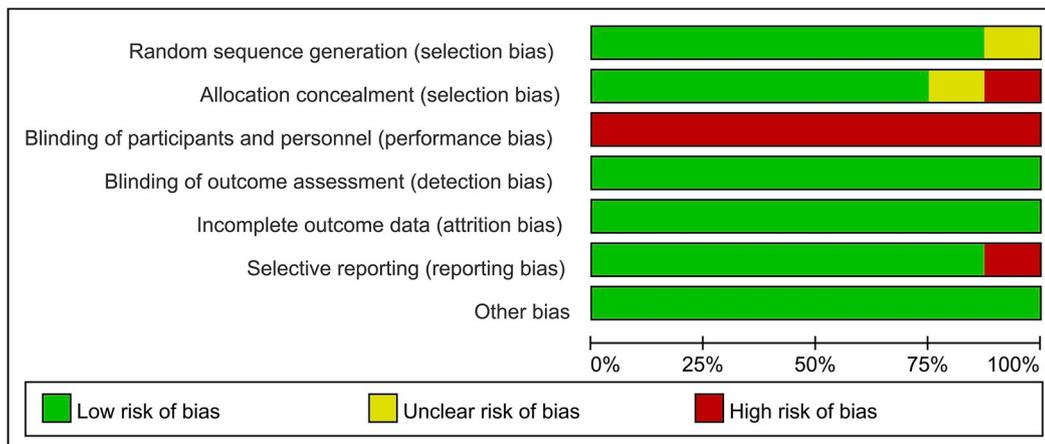


Fig. 2. ARisk of bias graph;
B. Risk of bias summary.

limitations. The meta-analysis, which pooled the effect size for pain scores, total opioid consumption, TUG test, distance walked, and length of stay, made no assessment of therapeutic effects occurring after 48 h. Second, heterogeneity among the included studies was unavoidable due to the different regimens of ACB and LIA used. Heterogeneity was also

caused by a variety of other factors, such as racial differences, tourniquet use, age differences, and mode of anesthesia. Third, some other minor factors such as differences in technique, time for block and drugs, concentration, amount and assessment techniques may affect the quality of results. To some extent, these factors was inevitable.

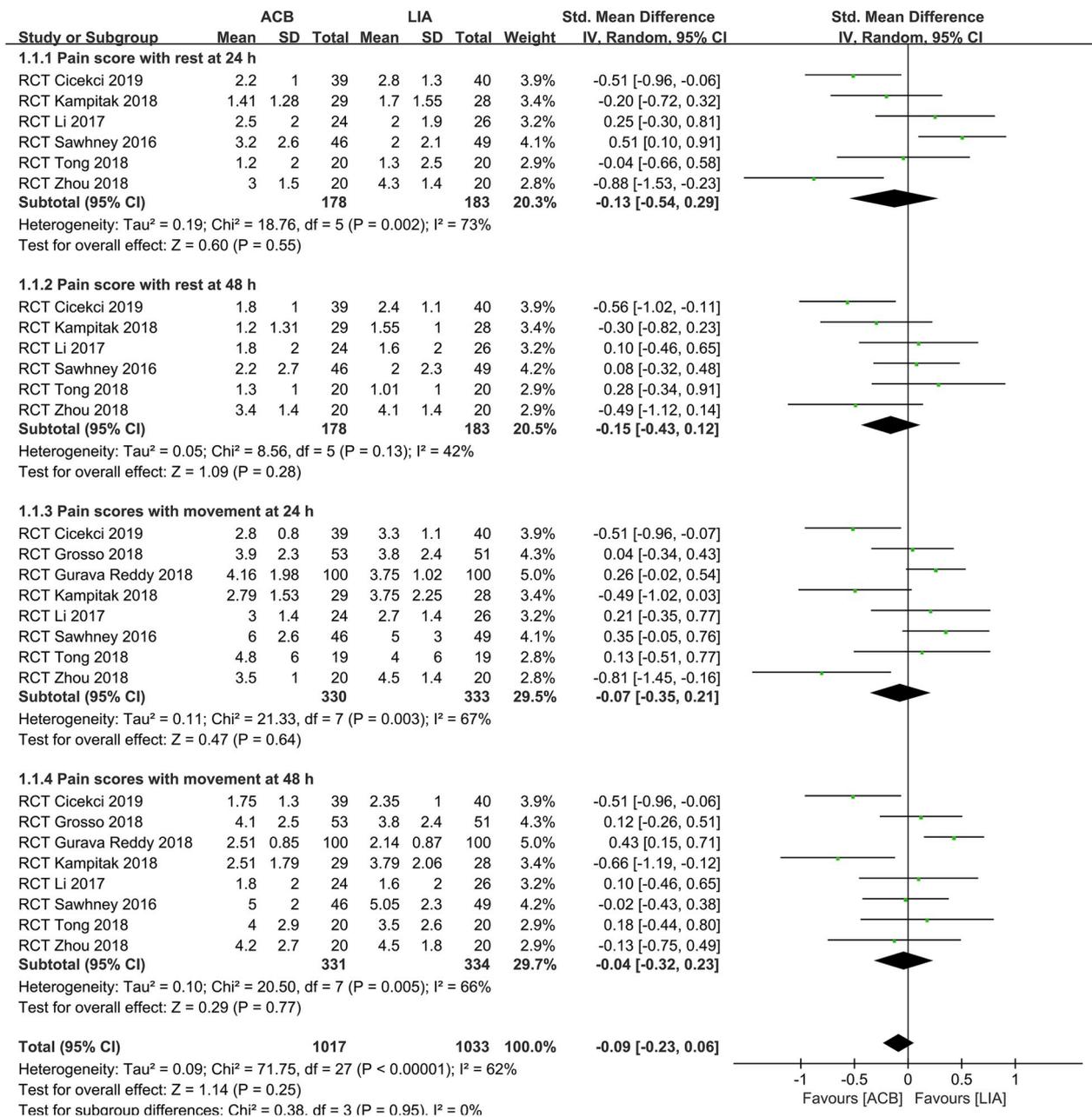


Fig. 3. Forest plots of the pain score between ACB group and LIA group after TKA.

Therefore, SMD was used to evaluate some outcomes in our meta-analysis. Fourth, publication bias is unavoidable because the identified language was restricted to English. Finally, owing to inconsistent reporting and diversity in the measurement methods, we failed to proceed with assessment of the knee ROM.

5. Conclusions

Both treatments provide similar overall pain relief after TKA. LIA may achieve earlier ambulation compared with ACB. More high-quality RCTs with long-term follow-up are still required to make the final conclusion.

Funding

None.

Conflicts of interest

None of the authors report conflict of interest.

Data statement

All data in this study were derived from the original literature.

Conflicts of interest

None.

Ethical approval

Ethical approval was not necessary because the present meta-analysis was performed on the basis of previous published studies.

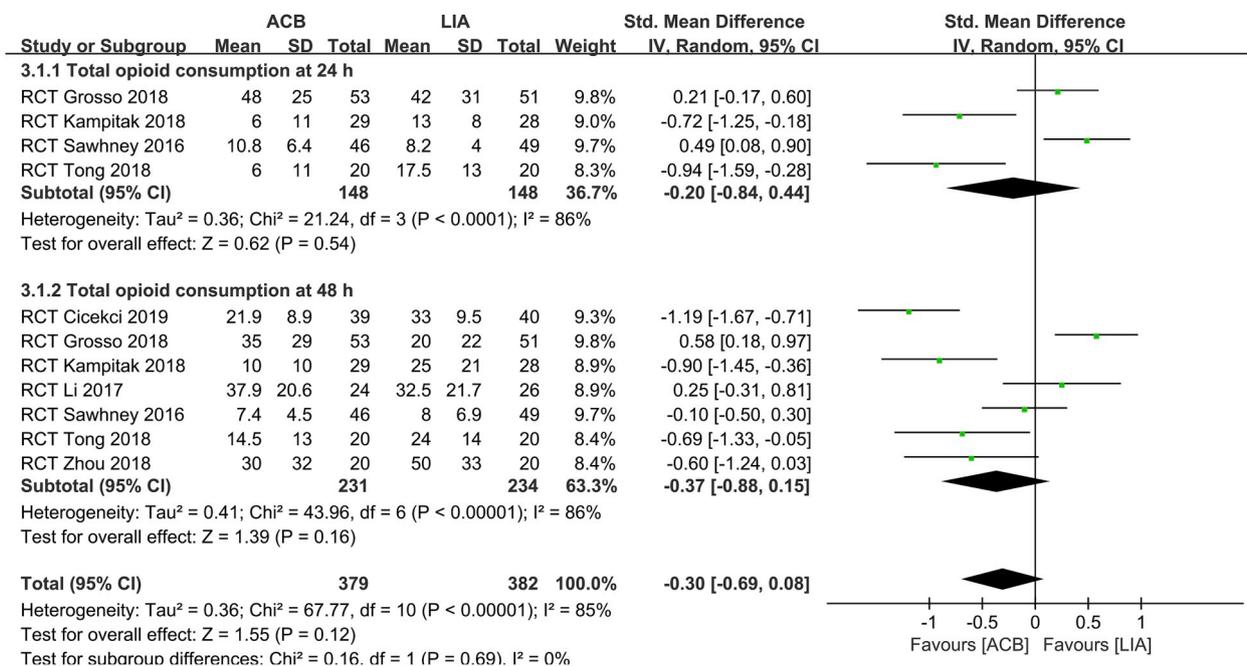


Fig. 4. Forest plots of the total opioid consumption between ACB group and LIA group after TKA.

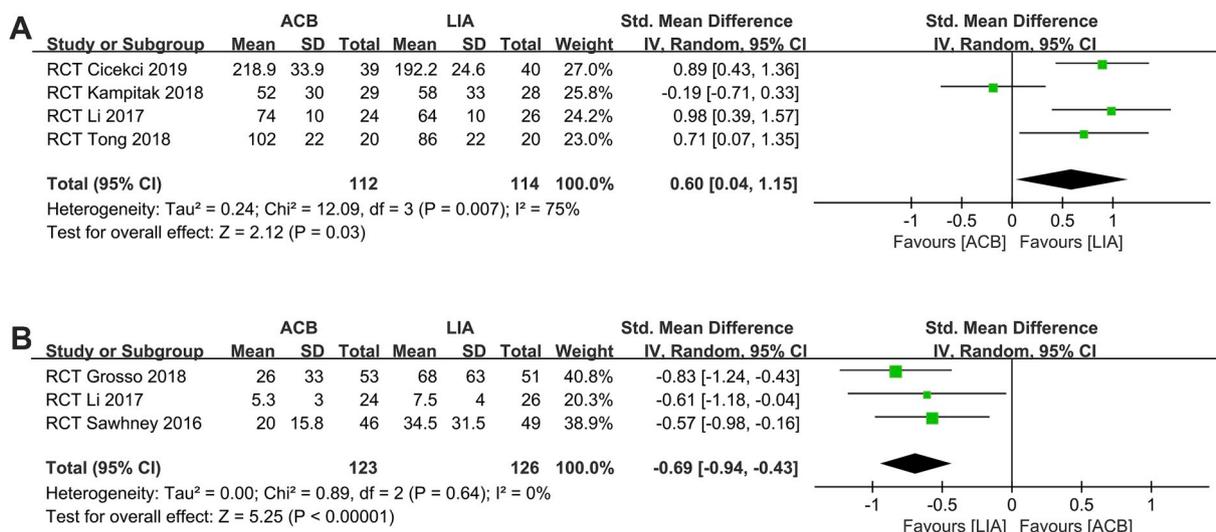


Fig. 5. A Forest plots of the TUG test at 24 h between ACB group and LIA group after TKA;

B. Forest plots of the distance walked at 24 h between ACB group and LIA group after TKA.

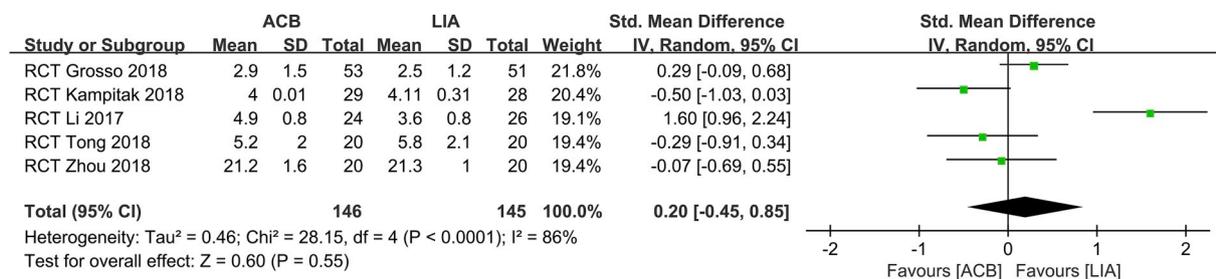


Fig. 6. Forest plots of the length of stay between ACB group and LIA group after TKA.

Research registration unique identifying number (UIN)

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Author contribution

Yiwen Zhao: first author, whole study: collection, data analysis writing. First reviewer of the included studies.

Zhihui Huang: collection. Did a pre-review of the full body of text.

Table 2
Results of meta-analysis.

Outcomes and Demographics	Number of Studies	Number of ACB	Number of LIA	SMD (95% CI)	P-Value	Heterogeneity	Level of Evidence
Pain scores with rest at 24 h	6	178	183	-0.13 (-0.54 to 0.29)	0.55	73% (R)	Low (2, 3, 4, 7)
Pain scores with rest at 48 h	6	178	183	-0.15 (-0.43 to 0.12)	0.28	42% (R)	Moderate (2, 3, 7)
Pain scores with movement at 24 h	8	330	333	-0.07 (-0.35 to 0.21)	0.64	67% (R)	Moderate (1, 2, 3, 4)
Pain scores with movement at 48 h	8	331	334	-0.04 (-0.32 to 0.23)	0.77	66% (R)	Moderate (1, 2, 3, 4)
Total opioid consumption at 24 h	4	148	148	-0.20 (-0.84 to 0.44)	0.54	86% (R)	Low (2, 3, 4, 7)
Total opioid consumption at 48 h	7	231	234	-0.37 (-0.88 to 0.15)	0.16	86% (R)	Very low (2, 4, 7)
Length of stay	5	146	145	0.20 (-0.44 to 0.85)	0.54	86% (R)	Low (2, 3, 4, 7)
TUG test at 24 h	4	112	114	0.60 (0.04–1.15)	0.03	75% (R)	Low (2, 3, 4, 7)
Distance walked at 24 h	3	123	126	-0.69 (-0.94 to -0.43)	< 0.00001	0% (R)	High (3, 7)

ACB, adductor canal blocks; LIA, local infiltrative analgesia; SMD, standardized mean differences; (R), random effects model was used.

Bold indicates a statistically significant P-value.

1, no details of randomization; 2, no concealment; 3, effect is stable; 4, result is inconsistent; 5, indirect data; 6, inconsistent follow-up time point; 7, limited sample size.

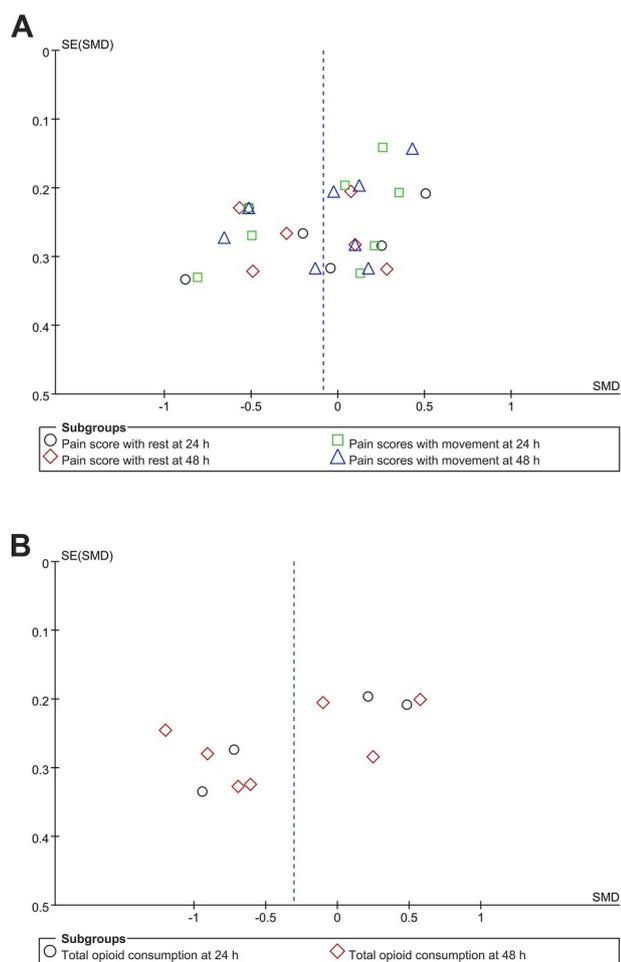


Fig. 7. A. Funnel plot of publication bias for the pain score between ACB group and LIA group after TKA. There was symmetry, suggesting that there was not a significant publication bias;

B. Funnel plot of publication bias for the total opioid consumption between ACB group and LIA group after TKA. There was symmetry, suggesting that there was not a significant publication bias.

Rewrote a significant and important part of the study.

Wenming Ma: (corresponding author): supervised the whole study.

Guarantor

Wenming Ma.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijvs.2019.07.024>.

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