

Effectiveness of continuous adductor canal block versus continuous femoral nerve block in patients with total knee arthroplasty

A PRISMA guided systematic review and meta-analysis

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Abstract

Background: This study aimed to evaluate the effectiveness of continuous adductor canal block (CACB) versus continuous femoral nerve block (CFNB) in postoperative analgesia and early rehabilitation of patients with total knee arthroplasty (TKA).

Methods: The Cochrane Library, PubMed, and EMBase were systematically searched to retrieve literature comparing efficacy of CACB versus CFNB on pain relief and functional recovery in knee replacement patients until December 2018, without language limitation. Meta-analysis was performed using RevMan 5.3 software.

Results: A total of 7 clinical randomized controlled trials and 4 retrospective studies were included, involving 484 cases in the CACB group and 491 in the CFNB group. The results of the meta-analysis showed that the visual analogue scores (VAS) at rest were similar between the CACB group and the CFNB group at 8 hours (standard mean difference(SMD)=-0.26, 95% confidence interval(CI): -0.62, 0.11), 12 hours (SMD=-0.02, 95%CI: -0.50, 0.47), 24 hours (SMD=0.05, 95%CI: -0.22, 0.33), and 48 hours (SMD=-0.10, 95%CI: -0.29, 0.09) after TKA ($P > .05$ for all). The muscle strength of patients in the CACB group post-operation was significantly improved than those of the CFNB group (SMD=0.81; 95% CI: 0.35, 1.26; $P = .0005$). There were no significant differences in the amount of opioids consumption and the incidence of postoperative fall between CACB and CFNB ($P > .05$).

Conclusion: The analgesic effects of CACB versus CFNB are equivalent after TKA. CACB has less effect on the quadriceps muscle strength, which is beneficial to the early postoperative activities and functional rehabilitation.

Abbreviations: ACB = adductor canal block, ACB = continuous adductor canal block, CFNB = continuous femoral nerve block, CI = confidence interval, MD = mean difference, NOS = Newcastle-Ottawa Scale, NRS = numeric rating scale, OR = odds ratio, PRISMA = preferred reporting items for systematic reviews and meta-Analyses, RCTs = randomized controlled trials, ROM = range of motion, SMD = standard mean difference, TKA = total knee arthroplasty, TUG = timed up and go test, VAS = visual analogue scores, WMD = weighted mean difference.

Keywords: adductor canal block, analgesia, femoral nerve block, meta-analysis, total knee arthroplasty

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1. Introduction

Total knee arthroplasty (TKA) is currently the most effective treatment for end-stage knee disease, but one of the most severely painful operations.^[1] It has been reported that almost 80% of the patients after surgery suffer from moderate, severe, or extreme pain.^[2] Postoperative pain affects the patient's physiological state, sleep and functional recovery. Pain can result in joint swelling, delayed recovery of muscle strength, decreased joint range of motion and decreased walking ability.^[3,4] These events can cause prolonged hospital stay, increased medical expenses, and decreased patient satisfaction.^[4,5] Compared with traditional analgesia methods such as epidural analgesia and intravenous analgesia pump, continuous femoral nerve block (CFNB) can provide satisfactory and effective analgesia for patients after TKA, reduce the use of opioids and complications such as nausea and vomiting, and it is considered as the gold standard for postoperative analgesia after TKA.^[6,7] However, it is reported that CFNB could weaken the quadriceps muscle strength and increase the risk of postoperative fall after TKA.^[8] In recent years, the adductor canal block (ACB) has received increasing attention, as it only blocks part of the sensory nerve and has less effect on

quadriceps muscle strength.^[9] With equivalent analgesic effect, ACB is beneficial to early postoperative functional exercise, shortens hospitalization time, improves patient satisfaction, and achieves rapid rehabilitation, and it is considered to be a potential substitute for CFNB.^[7,9]

However, there is still some controversy about the advantages of continuous ACB (CACB) compared to CFNB. Several studies^[10–13] have shown that the patients in the CACB group have better outcomes compared to those of the patients in the FNB group. There are other studies^[14,15] suggesting that although the quadriceps muscle strength of the patients in the CACB group was better than that of the CFNB group, the risk of postoperative fall, walking distance and functional rehabilitation were not significantly different. The studies by Mudumbai^[16] and Ztain^[17] showed that patients in the CACB group did not have shorter hospital stay compared to the CFNB group.

Therefore, there is still no satisfactory answer to the debate about the efficacy of CACB versus CFNB. In this study, we aimed to systematically evaluate the clinical efficacy of CACB versus CFNB by meta-analysis.

2. Methods

This systematic review and meta-analysis was not registered in the Cochrane registration database. This study was performed based on the guideline of the Cochrane handbook and the PRISMA items. This study was meta-analysis, therefore the ethical approval was not necessary.

2.1. Search strategy

Databases including the Cochrane Library, PubMed, and EMBASE were searched with the following terms: “(total knee arthroplasty or total knee replacement) AND (femoral nerve block) AND (adductor canal block or saphenous nerve block)” to identify potential eligible studies evaluating the efficacy of CFNB versus CACB in patients with TKA until September 2018 without language limitation, according to the search strategy recommended by the Cochrane Collaboration.

2.2. Inclusion and exclusion criteria

Inclusion criteria:

- (1) Study type: clinical randomized controlled trials or retrospective trials, regardless of study region;
- (2) Subjects: patients who underwent total knee arthroplasty without race, age, gender, weight, or primary disease limitations;
- (3) Interventions: comparison of continuous FNB versus ACB. Any disagreement of study selection was discussed by two reviewers or arbitrated by a third reviewer.

Exclusion criteria were as following:

- (1) Repeated publication of the population, except for reporting different outcomes;
- (2) case reports, reviews, guidelines or expert opinions;
- (3) animal studies, other knee operations rather than TKA, infection or revision surgery.

2.3. Literature screening and quality evaluation

The searched literature was screened by two reviewers based on the inclusion and exclusion criteria, independently. Each study title and abstract was carefully viewed by two researchers. It was

submitted to a third reviewer if there was controversy. The data extracted from the studies included: characteristics of the included studies, such as author, region, publication year, sample size, primary and secondary outcomes, as well as baseline characteristics of the included patients. The author was contacted if necessary to obtain more detailed data.

The methodological quality of the included randomized controlled trials (RCTs) was evaluated according to the randomized controlled trial evaluation criteria recommended by the Cochrane Handbook 5.1.0.^[18] There are five main aspects to be assessed, including randomization, concealment, blinding, selective reporting, and other source biases (such as significant baseline heterogeneity). According to the above criteria, the judgments of low bias, high bias and unclear bias are respectively made for each included study. The disagreement of methodological quality was solved by discussion or a third reviewer. For retrospective studies, the Newcastle-Ottawa Scale (NOS) evaluation method was used. According to the criteria of NOS, there are three main aspects to be noticed, and they are selection, comparability, and outcome.^[19] A maximum of nine stars can be given to a study based on the overall quality.

2.4. Publication bias

The publication bias is shown by the inverted funnel plot. If it was measurement data, its mean difference (MD) was used as the abscissa and the standard error of MD as the ordinate. If it was count data, its odds ratio (OR) was used for the horizontal coordinate and log OR as the ordinate. The impact of publication bias was assessed by observing its symmetry, and Begg and Egger test.

2.5. Statistical analysis

The meta-analyses were performed using the Review Manager 5.3 software provided by the Cochrane Collaboration. The mean difference (MD) or weighted mean difference (WMD) and its related 95% confidence interval (95% CI) was used to analyze data with same or similar measurement units, such as visual analog scale (VAS) pain score, quadriceps muscle strength, range of motion (ROM), standing walking test time (Timed up and Go test, TUG), hospitalization time and postoperative opioid analgesic drug consumption. The OR and its relevant 95% CI were used to analyze counting data. For heterogeneity analysis, a $P \geq .1$ or $I^2 < 50\%$ was considered to be homogenous. Therefore, the fixed effect model was applied. If significant heterogeneity was indicated, a random effect model analysis was used. Sensitivity analysis or subgroup analysis was conducted to find out the main source of heterogeneity and minimize the impact of heterogeneity on the results of meta-analysis. For combined analysis, a $P < .05$ was considered as there was a statistical significance with regard to the comparison.

3. Results

3.1. Searching results

After preliminary search, a total of 123 articles were obtained. After reading the title, abstract and full text, 16 repeated randomized controlled trials (RCTs) and 6 clinical retrospective studies were potential eligible for inclusion. Excluding animal studies, reviews, case reports, and other reasons, 11 clinical trials (10-17, 20-22) for postoperative analgesia after TKA were included, including 7 randomized controlled trials and 4

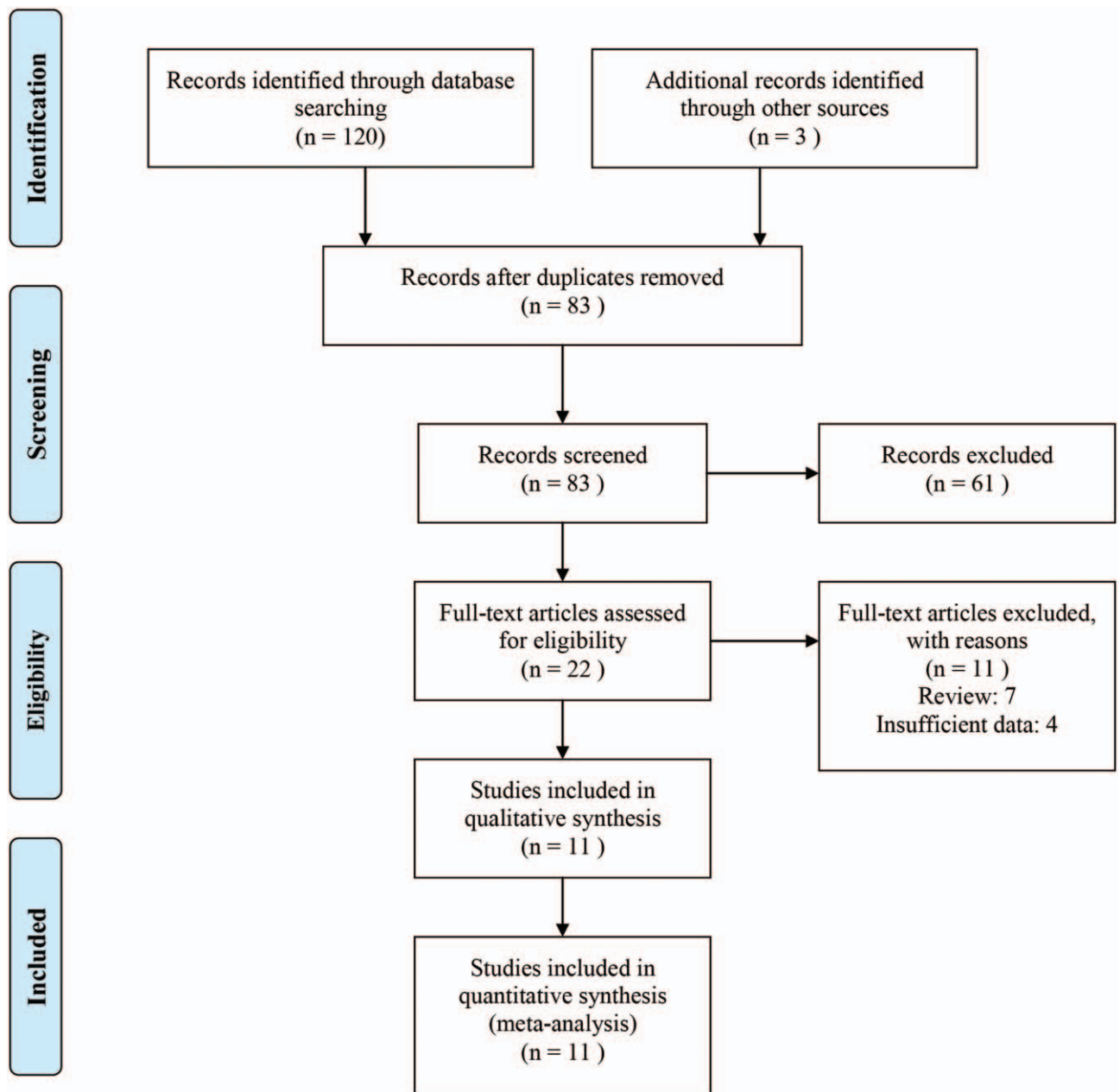


Figure 1. Process of identifying eligible studies for meta-analysis.

retrospective studies (Fig. 1). These studies were published in the period of 2013 to 2018. A total of 975 patients were included in the study, including 484 patients with ACB and 491 patients with FNB. Baseline comparisons were performed in each included study and the differences were not statistically significant as the included studies indicated. Table 1 provides general information on the included studies.

The methodological quality of RCT included in this study was high. These RCTs used follow-up methods, with all trials using randomization and four studies using blinding. The risks of loss of follow-up or withdrawal, selecting reports, or other types of bias in all RCTs were low. The included retrospective studies were of high methodological quality with NOS scores equal or above six stars. The quality evaluation of the included studies is shown in Table 2.

3.2. Results of meta-analysis

This meta-analysis aimed to assess the analgesic and clinical efficacy of CACB versus CFNB after TKA. The outcome measures included VAS pain score, quadriceps muscle strength, degree of knee extension and flexion, standing walking test time, length of hospital stay, postoperative opioid consumption, and postoperative fall risk.

3.3. VAS after TKA surgery

Six studies^[10,13,14,16,20,21] reported rest VAS from 8 hours to 48 hours after TKA, with a total of 487 patients, including 222 cases in the CACB group and 265 cases in the CFNB group. The results of the meta-analysis showed significant heterogeneity between the included studies ($P < .1$, $I^2 > 50\%$) for comparing VAS at 12

Table 1**Baseline characteristics of included studies.**

| Author | Year | Design | Number | | Region | Sex (Male) | Age | | ASA | Follow up | Outcomes |
|-------------|------|--------|--------|------|---------|------------|------------|------------|--------|-----------|---|
| | | | CACB | CFNB | | | CACB | CFNB | | | |
| Jager | 2013 | RCT | 25 | 29 | Europe | 19 | 70 ± 8 | 66 ± 9 | NA | 24 hours | Muscle tests of the quadriceps, pain, ROM, TUG, opioid dose, |
| Shah | 2014 | RCT | 48 | 50 | Asia | 27 | 68.3 ± 7.6 | 65.9 ± 7.2 | I-III | 48 hours | Ambulation ability (TUG, 10-m walk, 30 s chair test), staircase competency, ambulation distance, pain scores, opioid consumption, length of hospital stay |
| Zhang | 2014 | RCT | 30 | 30 | Asia | 14 | 63.7 ± 5.8 | 61.9 ± 6.7 | I-III | 48 hours | pain, quadriceps strength, complications |
| Machi | 2015 | RCT | 39 | 41 | America | 30 | 67 ± 8 | 66 ± 7 | NA | 72 hours | pain, opioid dose, ambulation distance, TUG, quadriceps, knee scores |
| Sztain | 2015 | RCT | 15 | 15 | America | 30 | 67 ± 8 | 66 ± 7 | NA | 72 hours | pain, opioid dose, ambulation distance, TUG, quadriceps, knee scores |
| Wiesmann | 2016 | RCT | 21 | 21 | Europe | 18 | 72 | 66 | I-III | 72 hours | TUG, opioid, pain, quadriceps, ambulation distance |
| Mudumbai | 2014 | RTS | 66 | 102 | America | 27 | 65 ± 9 | 66 ± 10 | II-III | 48 hours | opioid dose, pain, hospital stay, ambulation distance, |
| Brennan | 2018 | RTS | 142 | 104 | America | 61 | 73.2 ± 0.6 | 72.3 ± 0.8 | I-IV | 6 months | Muscle tests of the quadriceps, ROM of the knee, patient-oriented outcomes, and clinical knee scores |
| Thobhani | 2017 | RTS | 22 | 23 | America | 17 | 63 | 69 | II-IV | 48 hours | Pain, opioid dose, hospital stay, ambulation distance |
| Ardon | 2016 | RTS | 45 | 45 | America | 28 | 64.86 | 67.71 | NA | 48 hours | opioid dose, pain, adverse events |
| Elkassabany | 2016 | RCT | 31 | 31 | America | 21 | 63 ± 8 | 65 ± 8 | I-III | 7 days | Fall risk, muscle tests of the quadriceps, TUG, ambulation distance, pain, opioid dose, patient-oriented outcomes |

ASA = American Society of Anesthesiologists physical status, CACB = continuous adductor canal block group, CFNB = continuous femoral nerve block group, RCT = randomized controlled trial, NA = not available, ROM = range of motion, TUG = timed up and go, RTS = retrospective studies.

Table 2**Methodological quality evaluation of included studies.**

| Author | Year | Randomisation | Blinding | Allocation concealment | Incomplete reporting | Other bias |
|-------------|------|---------------|---------------|------------------------|----------------------|------------|
| Jager | 2013 | Y | Y | N | N | N |
| Shah | 2014 | Y | Y | N | N | N |
| Zhang | 2014 | Y | NR | N | N | NR |
| Machi | 2015 | Y | N | N | N | NR |
| Sztain | 2015 | Y | N | N | N | NR |
| Wiesmann | 2016 | Y | Y | N | N | NR |
| Elkassabany | 2016 | Y | Y | N | N | N |
| | | Selection | Comparability | Outcome | | |
| Mudumbai | 2014 | ★★★ | ★★ | ★★★ | | |
| Brennan | 2018 | ★★ | ★★ | ★★★ | | |
| Thobhani | 2017 | ★★★ | ★★ | ★★★ | | |
| Ardon | 2016 | ★★★ | ★★ | ★★ | | |

Randomized trials were assessed by the method of Cochrane Handbook 5.1. Retrospective studies were assessed by NOS method. Y = yes, N = no, NR = not reported.

hours and 24 hours, so the random-effect model was used. The combined data suggested that there were no statistical differences in resting VAS scores between the CACB group and the CFNB group at 8 hours (SMD = -0.26, 95% CI: -0.62, 0.11), 12 hours (SMD = -0.02, 95% CI: -0.50, 0.47), 24 hours (SMD = 0.05, 95% CI: -0.22, 0.33), and 48 hours (SMD = -0.10, 95% CI: -0.29, 0.09) after TKA ($P > .05$ for all) (Fig. 2A).

For the exercise VAS pain score, there was significant heterogeneity between the studies ($P < .1$, $I^2 > 50\%$), and a random effect model was used. By combining data from 3 studies,^[13,20,21] the exercise VAS pain scores were lower in the CACB group than those of the CFNB group at 24 hours (SMD = -0.08, 95% CI: -0.53, 0.37) and 48 hours (SMD = -0.10, 95% CI: -0.66, 0.45) after TKA. However, there were no significant differences between the two groups ($P > .05$ for all) (Fig. 2B). The above results indicate that there are no significant differences between CACB and CFNB with regard to resting and exercise VAS.

There were three studies^[15,17,22] evaluated the postoperative pain using numeric rating scale (NRS). The NRS pain scores were lower in the CFNB group than those of the CACB group at 12 hours (MD = 1.09; 95% CI: 0.36, 1.82; $P = .003$), 24 hours (MD = 0.66, 95% CI: -0.04, 1.35; $P = .06$) and 48 hours

(MD = 0.74, 95% CI: 0.05, 1.44; $P = .04$) after TKA (Supplemental Fig. 1A, <http://links.lww.com/MD/D394>).

3.4. Postoperative opioid consumption

Indicated by the heterogeneity test, the homogeneity between the included studies was poor ($P < .1$, $I^2 > 50\%$), so the random effect model was used. Six studies^[10,11,13,14,16,17] reported postoperative opioid doses at 2 hours, 4 hours, 8 hours, 24 hours and 48 hours after surgery with a total of 449 patients, including 204 cases in the CACB group and 245 cases in the CFNB group. The results showed that the differences of the opioids consumption between the 2 groups at above time points were SMD = 0.17 (95% CI: -0.13, 0.47), SMD = 0.39 (95% CI: -0.15, 0.93), and SMD = 0.59 (95% CI: -0.19, 1.37), SMD = 0.17 (95% CI: -0.19, 0.53), SMD = 0.18 (95% CI: -0.20, 0.56), respectively ($P > .05$ for all) (Fig. 3).

3.5. Knee Function

3.5.1. Quadriceps muscle strength. Three studies^[14,21,22] reported quadriceps muscle strength at 24 hours after surgery, with a total of 164 patients, including 82 cases in the CACB group and 82 cases in the CFNB group. The results of the meta-analysis

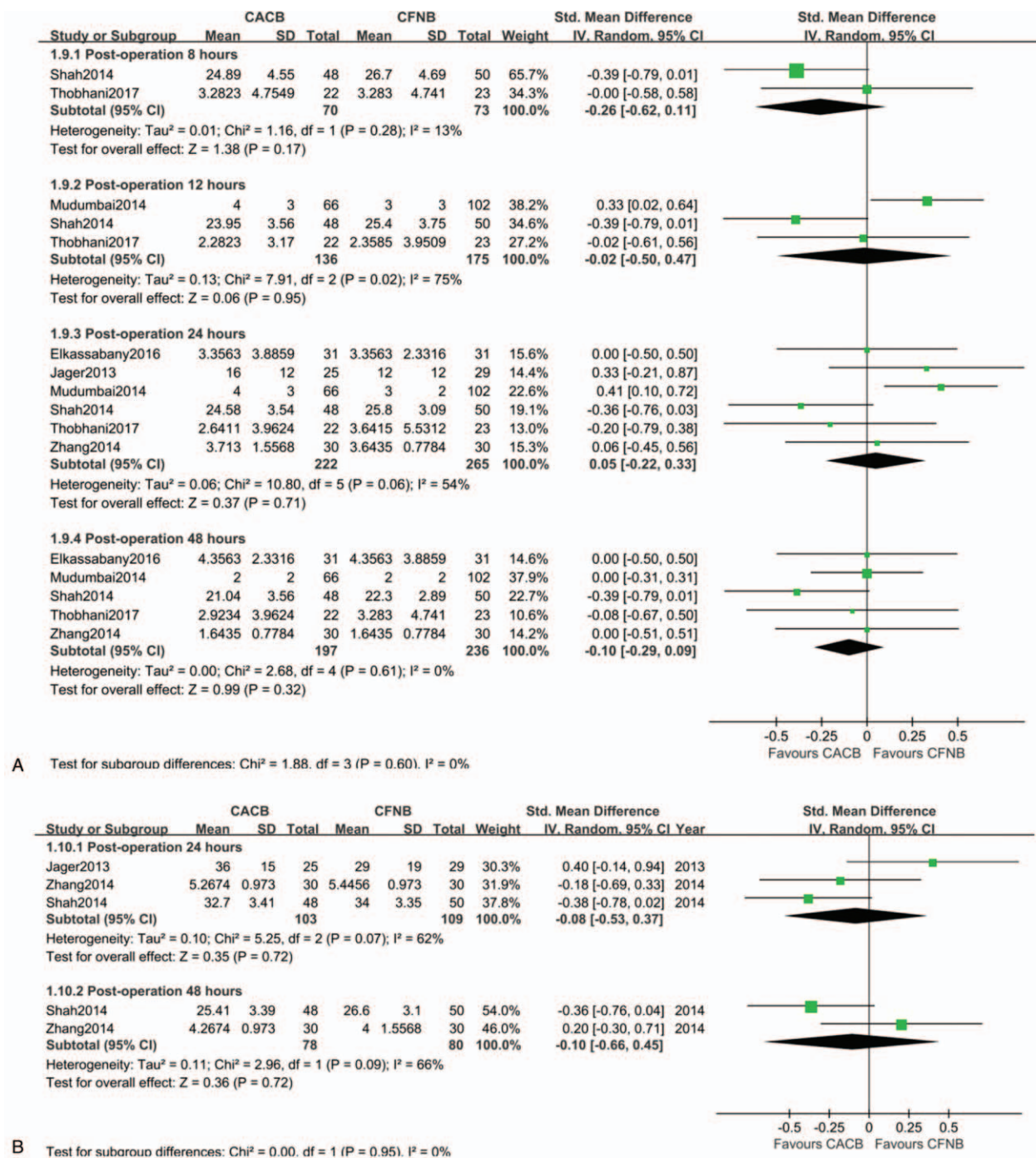


Figure 2. Forest plot of comparison: CACB vs CFNB for controlling pain, outcome: VAS. A, VAS at rest; B, VAS at activity.

showed that there was a moderate but not significant heterogeneity between the studies ($P > .1$, $I^2 = 50\%$), so the random effect model was applied. The quadriceps muscle strength of the CACB group was significantly better than that of the CFNB group at the above time point, and the difference of the muscle strength was 0.81(95% CI: 0.35-0.61.26; $P = .0005$) (Fig. 4A).

3.5.2. Postoperative extension and flexion degree. Five studies reported degree of extension and flexion after TKA with a total of 454 patients, including 244 cases in the CACB group, and 210 cases in the CFNB group. The results of the meta-

analysis showed that the heterogeneity between the studies was not significant ($P > .1$), so the fixed effect model was used. The differences for extension and flexion degree between the two groups were $\text{MD} = -1.18$ (95% CI: -1.29, -1.07; $P < .01$) and $\text{MD} = 0.11$ (95% CI: -0.17, 0.38; $P > .05$), respectively (Fig. 4B). These results suggested that the extension degree of knee in the CACB group was lower than the CFNB group after surgery.

3.5.3. Rehabilitation

3.5.3.1. Discharge readiness. Two studies^[15,17] reported time of discharge readiness after TKA with a total of 110 patients,

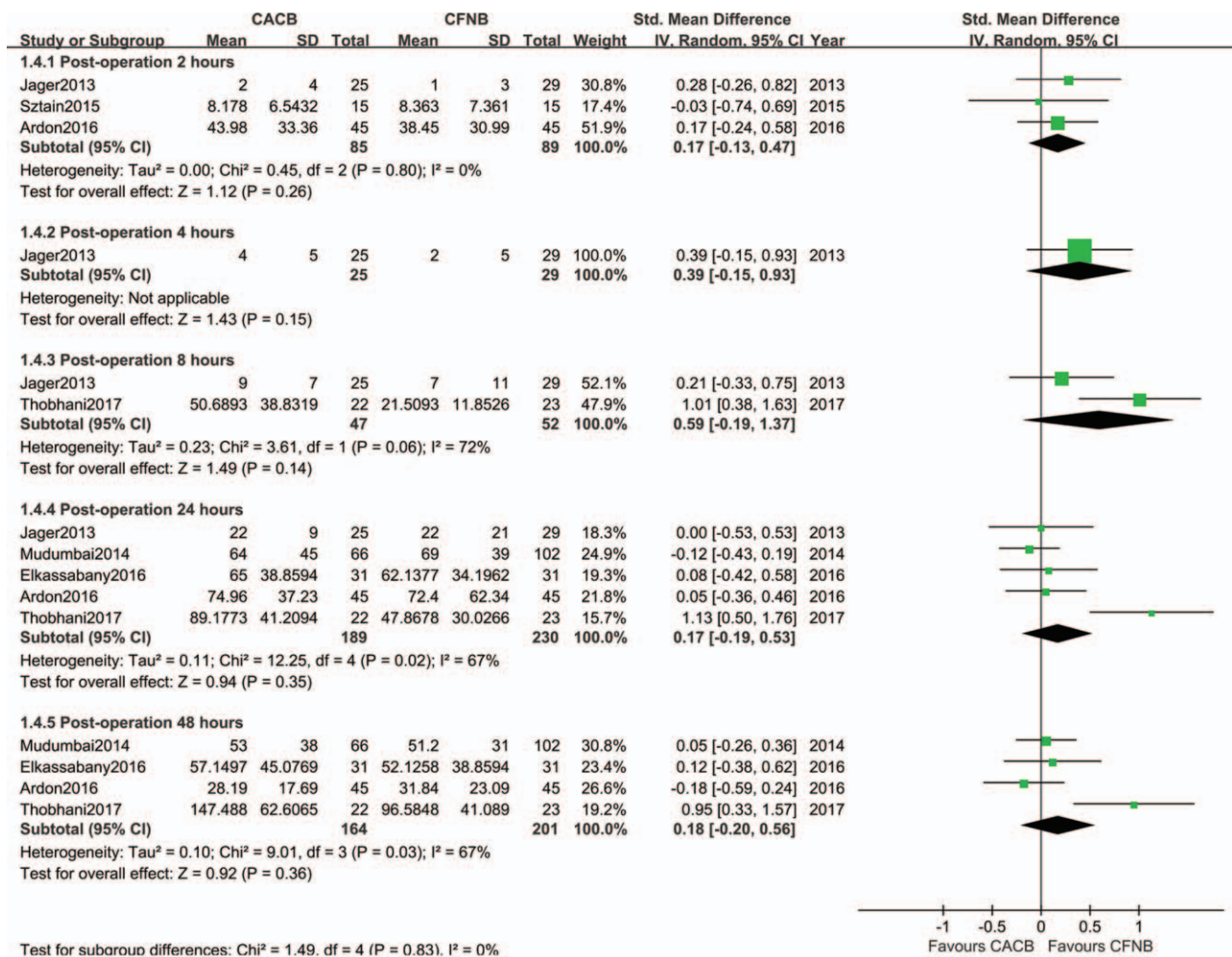


Figure 3. Forest plot of comparison: CACB vs CFNB for opioid consumption.

involving 54 participants in the CACB group, and 56 cases in the CFNB group. The results of the meta-analysis showed that the heterogeneity between the studies was low ($P > .1$, $I^2 = 0\%$), so a fixed effect model was used. The mean difference in standing walking time between the 2 groups was -7.03 (95% CI: $-13.55, -0.50$; $P = .03$), suggesting that patients in the CACB group had shorter time of discharge readiness than those in the CFNB group (Fig. 5A).

3.5.3.2. Ambulation distance. Three studies^[10,14,16] reported standing walking distance in 275 patients, including 119 cases in the CACB group, and 156 cases in the CFNB group. The results of the meta-analysis showed that the heterogeneity between the studies was significant ($P = .1$, $I^2 > 50\%$), so a random effect model was used. The mean difference in standing walking distance between the two groups was 18.82 (95% CI: $2.0, 35.65$), suggesting that patients in the CACB group had longer walking distance than those in the CFNB group (Fig. 5B).

3.5.3.3. TUG. Three studies reported postoperative TUG time after surgery in a total of 158 patients, including 77 cases in the CACB group and 81 cases in the CFNB group. As indicated by

the heterogeneity test, the homogeneity between the included studies was good ($P > .1$, $I^2 = 0\%$), so the fixed effect model was used (Fig. 5C). The results showed that the mean difference of the TUG time between the 2 groups was -5.22 (95% CI: $-13.49, 3.05$; $P > .05$).

3.5.3.4. Fall risk. Two studies^[15,17] reported the postoperative incidence of fall among 54 patients in the CACB group and 56 in the CFNB group. The results showed that the risk of fall was lower in the CACB group than that of the CFNB group, though there was no significant difference (OR = 0.45 , 95% CI: $0.10-2.07$; $P = .30$) (Fig. 5D).

3.5.3.5. Postoperative hospital stay. Three studies^[15,16,20] reported days of postoperative hospital stay, involving 153 patients in the CACB group, and 193 in the CFNB group. As shown in supplemental Fig. 1B, <http://links.lww.com/MD/D394>, the results of the meta-analysis showed that the heterogeneity between the studies was significant ($P < .1$, $I^2 = 96\%$), and a random effect model was used. The combined result showed that the SMD was -0.74 (95% CI: $-1.93, 0.45$), suggesting that patients in the CACB group had shorter postoperative hospital stay days than those in the CFNB group.

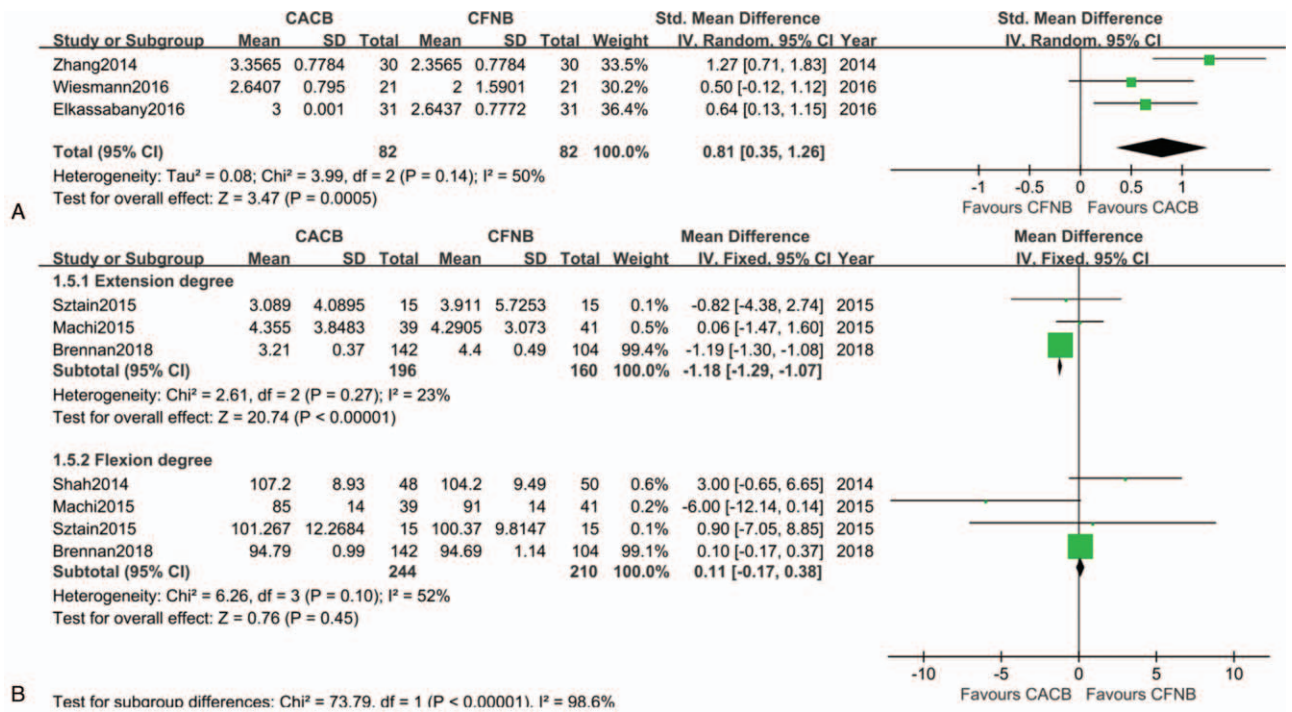


Figure 4. Forest plot of comparison: CACB vs CFNB for patients with TKA, outcome: Knee function. A, Quadriceps strength; B, extension and flexion degrees of knee after surgery.

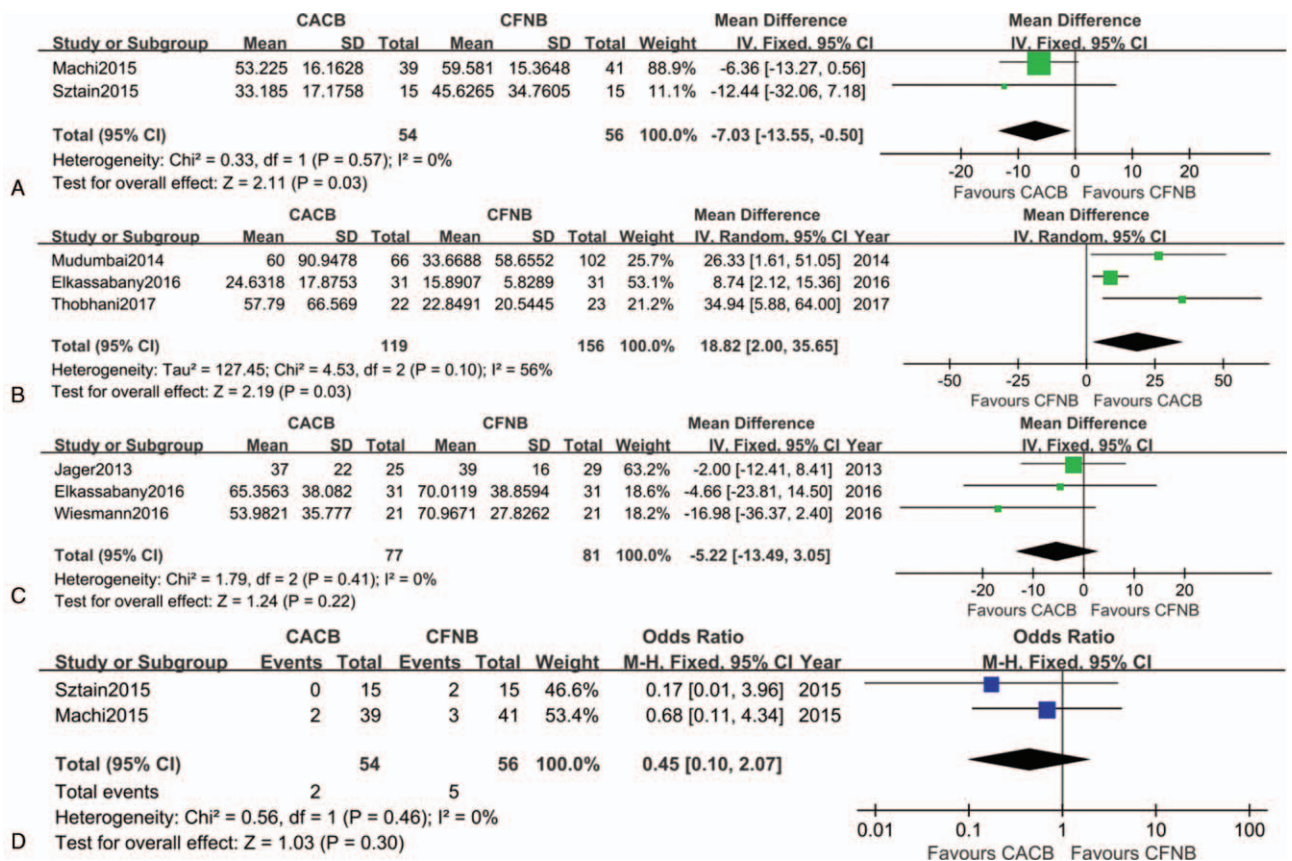


Figure 5. Forest plot of comparison: CACB vs CFNB for patients with TKA, outcome: function recovery. A, time of discharge readiness; B, ambulation distance; C, TUG test; D, fall risk.

3.5.3.6. Publication bias. As illustrated by the funnel plots with regard to pain control (Supplemental Fig. 2A, <http://links.lww.com/MD/D395>) and opioid consumption (Supplemental Fig. 2B, <http://links.lww.com/MD/D395>), the scatter points were basically symmetrical, indicating there was less possibility of publication bias.

4. Discussion

This meta-analysis compared pain management and knee joint function recovery between CACB versus CFNB after TKA, and analyzed which method had better clinical outcomes after surgery. Our results showed that postoperative quadriceps muscle strength and TUG test in the CACB group were better than those of the CFNB group, indicating that patients in the CACB group have better mobility and earlier functional recovery after TKA. In the early postoperative period (8 hours), the resting pain VAS score in the CACB group was lower than that in the CFNB group, but there was no significant difference as well as other postoperative time points of resting and dynamic VAS.

Previous studies^[23,24] showed that saphenous nerve block had a good effect on pain control after knee joint replacement during dynamic and resting conditions, and the effect of ACB was proved to be equivalent to FNB.^[25] Currently, the standard method of pain control after TKA is FNB, but there are some serious complications such as quadriceps muscle strength reduction, delayed activity and increased clinical fall events,^[26] but the relative blockage of the myocardium has lower risk of these obvious complications.^[27]

The potential sources for heterogeneity were as following: first, the tolerance to pain may differ between different races and regions. We included patients that were located in different regions such as Asian, European or American. These patients may have different tolerance for pain and sensitivity to analgesic medication.^[28] Second, the baseline characteristics may differ between included studies, though it was not significant within a study. These factors included age, sex, race, different disease history, surgery time and trauma, contributing to deviations of pain evaluation and recovery of joint function. Thirdly, bilateral and unilateral TKA may have a different impact on pain score.^[29]

Though we tried to minimize risk of bias by introducing specific inclusion and exclusion criteria, there were still few limitations in this study. First, only limited number of RCT and participants were included. The relatively small sample size may be the reason why there were no statistical differences between several outcomes, such as dynamic VAS scores, postoperative analgesic drugs consumption, and length of hospital stay. Second, the different anesthesia methods used in different studies may affect postoperative pain scores, and introduce heterogeneity as mentioned above. In addition, besides ACB and FNB, other analgesic methods were also tested in few included studies. These may increase the risk of bias. Thirdly, only short-term effects after surgery were included and analyzed, and the long-term effect of CACB versus CFNB on pain control and knee joint function recovery was still needed to be evaluated.

5. Conclusion

CACB after TKA not only achieves similar pain control effect as the CFNB but also allows patients to obtain better quadriceps muscle strength and mobility, resulting in faster functional

recovery. Therefore, CACB may serve as an alternative to CFNB as a standard method for pain control in patients with TKA.

Author contributions

Conceptualization: Yuanyuan Liu.

Data curation: Zhen Zhang.

Formal analysis: Yu Wang, Yuanyuan Liu.

Investigation: Yu Wang, Yuanyuan Liu.

Methodology: Zhen Zhang, Yu Wang, Yuanyuan Liu.

Project administration: Yuanyuan Liu.

Software: Zhen Zhang, Yu Wang, Yuanyuan Liu.

Validation: Yu Wang, Yuanyuan Liu.

Visualization: Yuanyuan Liu.

Writing – original draft: Zhen Zhang, Yuanyuan Liu.

Writing – review & editing: Yuanyuan Liu.

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