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Comparison of adductor canal block and femoral nerve block for pain management in anterior cruciate ligament reconstruction

A meta-analysis of randomized controlled trials

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Abstract

Objective: To compare the efficacy of adductor canal block and femoral nerve block for pain management in patients with anterior cruciate ligament reconstruction.

Methods: A computerized search was performed in the database of PubMed, Embase, Web of Science and Cochrane Library for randomized controlled trials. The outcome measures included visual analog scale, morphine consumption, quadriceps strength, length of hospitalization and postoperative adverse events. The risk of bias of randomized controlled trials was assessed according to the Cochrane Risk of Bias Tool. All quantitative syntheses were completed using STATA version 14.

Results: Seven randomized controlled trials involving a total of 643 patients were included in our meta-analysis. The present meta-analysis indicated that there were no significant differences between the 2 groups in terms of postoperative pain score, opioid consumption, length of hospitalization or adverse effects after anterior cruciate ligament reconstruction. However, adductor canal block showed superior quadriceps strength and range of motion in the early postoperative period.

Conclusion: Adductor canal block shows similar and adequate analgesia compared to the femoral nerve block in anterior cruciate ligament reconstruction and adductor canal block can preserve a higher quadriceps strength and better range of motion.

Abbreviations: ACB = adductor canal block, ACL = anterior cruciate ligament, FNB = femoral nerve block, RCT = randomized controlled trial.

Keywords: adductor canal block, anterior cruciate ligament reconstruction, femoral nerve block, meta-analysis

1. Introduction

Anterior cruciate ligament (ACL) reconstruction is a common surgical procedure, performed using part of the patella tendon or hamstring tendon to reconstruct the cruciate ligament.[1] ACL injury mainly occurs in the physically active population, often from participation in a sport or recreational activity.[2] It is reported that there are approximately 200 thousand ACL injuries per year in the United States and nearly 130 thousand of them requires surgical arthroscopic surgery.[3,4] It has been one of the most popular minimally invasive surgery. However, it is associated with moderate to severe postoperative pain which can prolong length of hospitalization and increase the risk of complications. Although various analgesic methods have been implemented to achieve a high degree of patient satisfaction, including local infiltration analgesia, peripheral nerve block, epidural analgesia and oral nonsteroidal anti-inflammatory drugs (NSIDAS),[5–7] none of the treatments are free from limitations such as the requirement of morphine.

Femoral nerve block (FNB) has long been used for pain management and demonstrates definite outcomes in knee surgery. However, one of the main weaknesses of the FNB is a temporary motor block of the quadriceps muscle, which may delay rehabilitation process and cause risk of falls.[8] Adductor canal block (ACB) is an alternative regional technique acts on multiple afferent sensory nerves within an aponeurotic tunnel in the middle-third of the thigh to extend pain treatment. Recent studies have reported that the analgesic effects of continuous

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Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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ACB versus continuous FNB are equivalent after total knee replacement.[9,10] However, few studies focus on the comparison between these 2 regional techniques in ACL reconstruction and there is no high quality systematic study to provide the objective evidence for clinical treatment. Therefore, we conduct this meta-analysis of randomized controlled trials (RCTs) to compare the clinical efficacy and safety between FNB with ACB in treatment of ACL reconstruction surgery.

2. Materials and methods

This study was approved by institutional ethical review board of our institution and was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Ethical approval and patient consent are not required because this study is a literature-based study.

2.1. Search strategy

A computerized search was performed in the database of PubMed, Embase, Web of Science, and Cochrane Library for published articles. No time frame was specified with respect to publication date and there was no language restriction. The following keywords were used along with the Boolean operator: cruciate ligament reconstruction, femoral nerve block, adductor canal block, knee and arthroscopic. Manual search of bibliographies from reviews and selected studies was also performed for additional articles.

2.2. Eligibility criteria and study selection

Articles included in the meta-analysis should meet the following inclusion criteria in the PICOS order:

1. population: imaging confirmed patients with ACL injury and had surgical indication;
2. experimental intervention: treated with FNB for postoperative analgesia;
3. comparison intervention: treated with ACB;
4. outcome measures: postoperative visual analog scale (VAS), morphine consumption, quadriceps strength, length of hospitalization and post-operative adverse events;
5. study design: RCT.

Exclusion criteria were as follows:

1. animal study;
2. gray literature without detailed information, data, or full text; and
3. studies without results mentioned above.

Two reviewers independently assessed the titles and abstracts for initial screening of studies, and then the full texts of articles selected from initial screening were evaluated. Disagreement was resolve by discussion and consensus. When the decision was still not reached, a third reviewer's opinion was sought.

2.3. Data extraction

Two reviewers independently extracted the following descriptive information from the included articles: study characteristics such as author, publication year, study design, sample size, type of analgesia, follow-up duration, key elements of bias risk assessment and outcome measures. Primary outcome measures included VAS score and morphine consumption. Secondary outcomes included length of hospitalization, muscle strength and adverse events. The corresponding author was contacted to request missing data. Any disagreement between reviewers was resolved by a third reviewer.

2.4. Risk of bias assessment

The risk of bias of RCTs was graded as high, low, or unclear according to the Cochrane Risk of Bias Tool[11] based on the following domains: selection bias, performance bias, detection bias, attrition bias, reporting bias and other bias. Other bias was defined as the study with unbalanced baseline characteristic of patients between groups. Two reviewers independently assessed the risk of bias of included RCTs. The evidence grade was assessed using the guidelines of the Recommendations Assessment, Development and Evaluation (GRADE) system.[12] The evidence grades were divided into the following categories:

1. high: further research is very unlikely to change confidence in the estimate of effect;
2. moderate: further research is likely to have an important impact on confidence in the estimate of effect and may change the estimate;
3. low: further research is very likely to have an important impact on confidence in the estimate of effect and is likely to change the estimate; and
4. very low: any estimate of effect is very uncertain.

2.5. Statistical analysis

All quantitative syntheses were completed using STATA version 14. Risk ratio (RR) with a 95% confidence interval (CI) or weight mean difference (WMD) with 95% CI were assessed for dichotomous outcomes or continuous outcomes. Heterogeneity was evaluated using the Q statistical test, and the P value and I^2 statistic. P values $\leq .10$ were deemed to indicate significant heterogeneity, and pooled results were then estimated using a random-effects model. When heterogeneity was not apparent ($P > .10$), a fixed-effects model was employed. Finally, publication bias was assessed by drawing contour-enhanced funnel plots. When these plots were not obviously asymmetric, we considered that publication bias was absent.

3. Results

3.1. Literature search

The initial literature search identified 165 studies. After duplicates removed, titles and abstracts of 44 studies were assessed. After evaluating 44 full texts, 37 articles were then further excluded for reasons such as conference abstract, reviews, case reports and no comparison of intervention and control group. Finally, 7 studies[13–19] that met the inclusion criteria were included in this meta-analysis. The reference lists of all the articles were also reviewed. The process and results of literature screening were shown in Figure 1.

3.2. Study characteristics

All included RCTs were published between 2014 and 2019, and involved 308 participants in FNB groups and 335 participants in ACB groups. All included patients underwent ACL reconstruc-

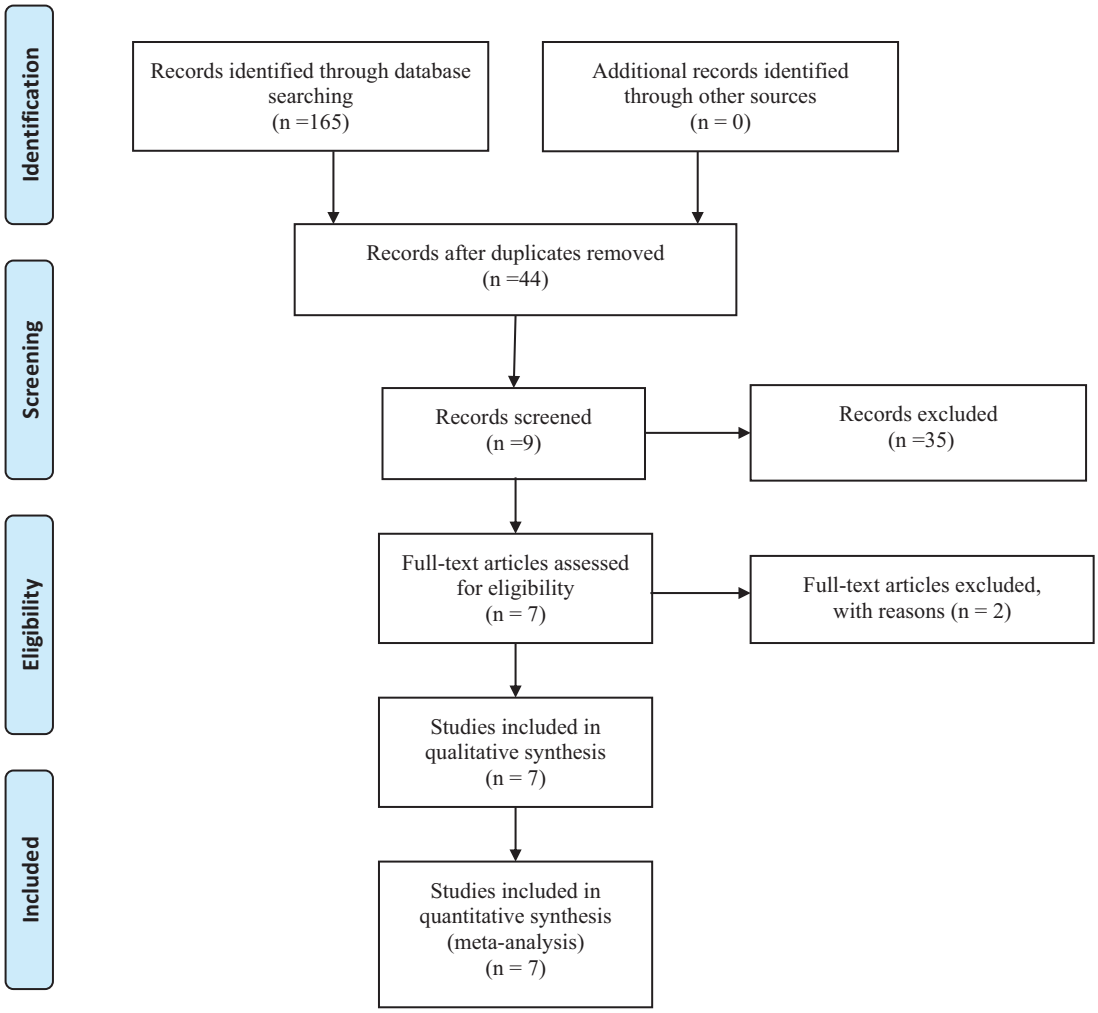

Figure 1. Flow diagram of included studies.

tion surgery. The mean age of the participants in each study ranged from 21 to 32 and follow up period ranged from 1 week to 6 months. The main characteristics of the included studies were described in Table 1.

Table 1

Characteristics of the included studies.

Study	Year	Design	Country	No. of patients FNB ACB	Mean age FNB ACB	Female gender FNB ACB	Interventions	Follow up
Chisholm	2014	RCT	USA	41 39	28 28	11 14	FNB: 30 mL of 0.25% bupivacaine with epinephrine 1:200,000 ACB: 10 mL bupivacaine 0.5% with epinephrine 1:200,000	2 wks
Ahl	2015	RCT	Egypt	64 64	28 27	6 11	FNB: 15 mL of ropivacaine 0.5% ACB15 mL of ropivacaine 0.5%	1 wk
Abdallah	2016	RCT	Canada	48 52	33 32	22 14	FNB: 20 mL ropivacaine 0.5% with epinephrine 1:200,000 ACB: 20 mL ropivacaine 0.5% with epinephrine 1:200,000	2 wks
Ghodki	2018	RCT	India	30 30	25 26	3 6	FNB: 20 mL of 0.5% ropivacaine ACB: 20 mL of 0.5% ropivacaine	1 wk
Runner	2018	RCT	USA	35 38	24 25	20 22	FNB: 20 mL of 0.5% ropivacaine ACB: 20 mL of 0.5% ropivacaine	6 mo
Bailey	2019	RCT	USA	38 40	24 21	18 17	FNB: 30 mL of 0.2% ropivacaine with 100 mcg clonidine ACB: 15 mL of 0.2% ropivacaine with 100 mcg clonidine	6 mo
Lynch	2019	RCT	USA	30 29	22 21	15 11	FNB: 30 mL of 0.5% ropivacaine ACB: 20 mL of 0.5% ropivacaine	1 wk

ACB = adductor canal block, FNB = femoral nerve block, RCT = randomized controlled trial.

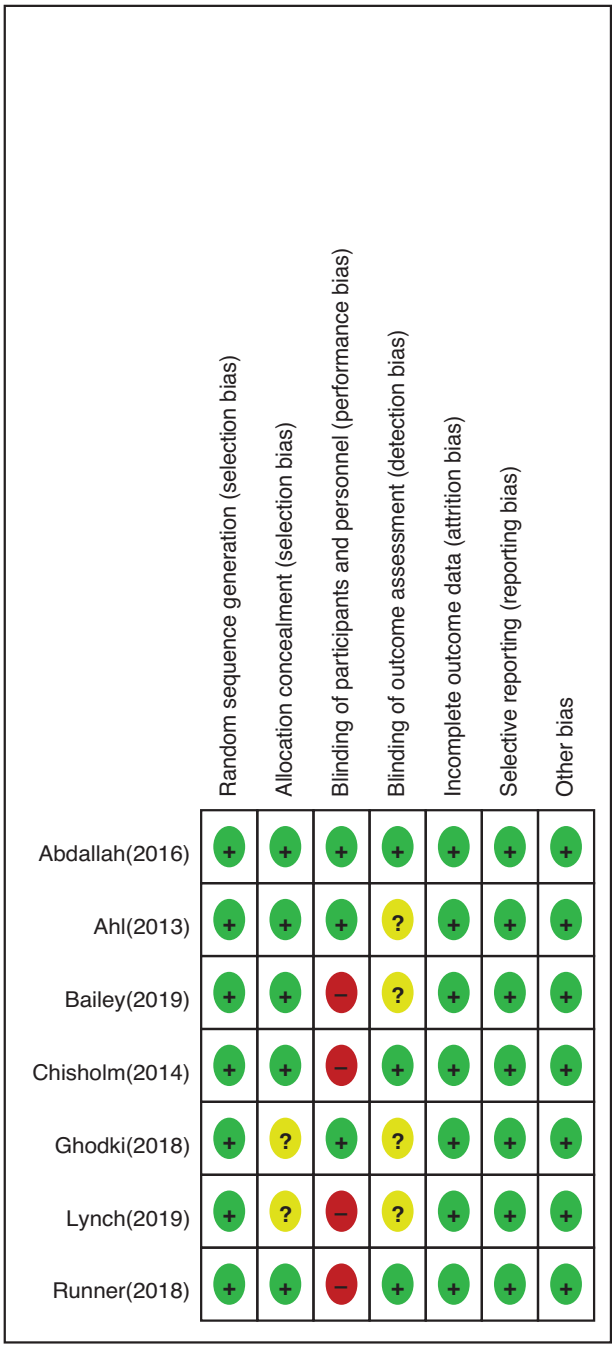

Figure 2. Risk of bias summary.

3.3. Risk of bias

All trials showed low risk of bias in the randomization process. Five of the 7 trials performed allocation concealment. Three trials utilized double blinding of participants and surgeons and 3 studies attempted to blind clinical assessors. All studies demonstrated a low risk of selective reporting and incomplete outcomes. We drew risk of bias graphs. That risk for each RCT was presented as a percentage of that of all included studies in Figure 2, and the risk of bias for each individual study was shown in Figure 3.

3.4. Results of meta-analysis

3.4.1. VAS score at 6 hours. A total of 6 studies provided the data on VAS score at 6 hours. Our studies indicated that there was no significant difference between the 2 groups regarding to VAS score at 6 hours (WMD = −0.221; 95% CI: −0.522–0.080; $P = .150$; Fig. 4).

3.4.2. VAS score at 12 hours. Pain score at 12 hours comparing FNB with ACB were available in 6 RCTs. The results regarding the pain score at 12 hours revealed no significant difference in the FNB group compared to the ACB group (WMD = −0.131; 95% CI: −0.421–0.160; $P = .377$; Fig. 5.)

3.4.3. VAS score at 24 hours. All RCTs reported the VAS score at 24 hours after ACL reconstruction. The present meta-analysis demonstrated that there was no significant difference between the 2 groups in terms of VAS score at 24 hours (WMD = −0.180; 95% CI: −0.749–0.389; $P = .536$; Fig. 6).

3.4.4. Morphine consumption at 24 hours. Six RCTs reported the outcome of the morphine consumption at 24 hours. Our meta-analysis revealed that both FNB and ACB therapies were equally effective reducing the morphine consumption at 24 hours (WMD = −2.796; 95% CI: −5.840–0.248; $P = .072$; Fig. 7).

3.4.5. Morphine consumption at 48 hours. Four RCTs reported the morphine consumption at 48 hours after ACL reconstruction. There was no significant difference between groups regarding to morphine consumption at 48 hours (WMD = −1.689; 95% CI = −6.258–2.879; $P = .469$, Fig. 8).

3.4.6. Muscle strength of lower limb. Muscle strength was reported in 4 studies. We calculated the percentage of patient whose muscle strength was level V. This review reflected that ACB was associated with a significant improvement of muscle strength of lower limb compare with FNB. (RR = 0.742; 95% CI = 0.580–0.950; $P = .018$, Fig. 9).

3.4.7. Range of motion. Range of motion was reported in 3 studies. This review reflected that ACB was associated with a significant improvement of range of motion compare with FNB (WMD = 7.003; 95% CI = 0.507–13.499; $P = .034$, Fig. 10).

3.4.8. Patient satisfaction. Four RCTs assessed patient satisfaction at 24 hours after surgery. The present meta-analysis indicated that no significant difference was found in terms of patient satisfaction (WMD = 0.084; 95% CI = −0.340–0.507; $P = .699$, Fig. 11).

3.4.9. Incidence of nausea and vomiting. Five studies reported the incidence of nausea and vomiting. A fixed-effect model was applied ($I^2 = 0\%$, $P = 881$). Our meta-analysis revealed that there was no significant difference between groups (RR = 1.078; 95% CI: 0.842–1.380; $P = .551$; Fig. 12).

3.4.10. Publication bias. As illustrated by the funnel plots with regard to postoperative pain score at 24 hours, the scatter points were basically symmetrical, indicating there was less possibility of publication bias (Fig. 13).

3.4.11. Quality of the evidence. The mains results in our study were assessed utilizing the GRADE system. The evidence quality for each outcome was moderate or low (Table 2). Therefore, we agreed that the overall evidence quality was low. Further

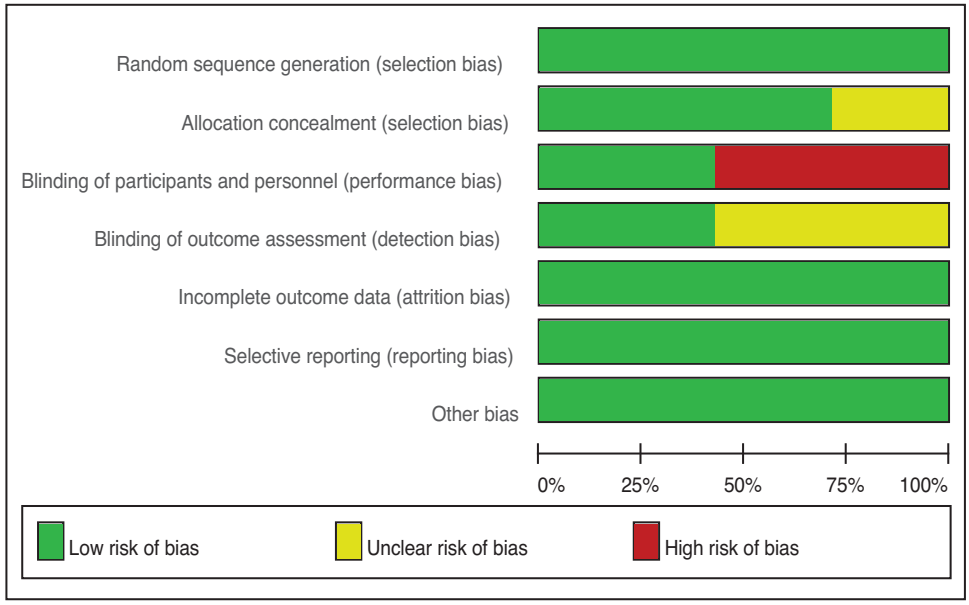

Figure 3. Risk of bias graph.

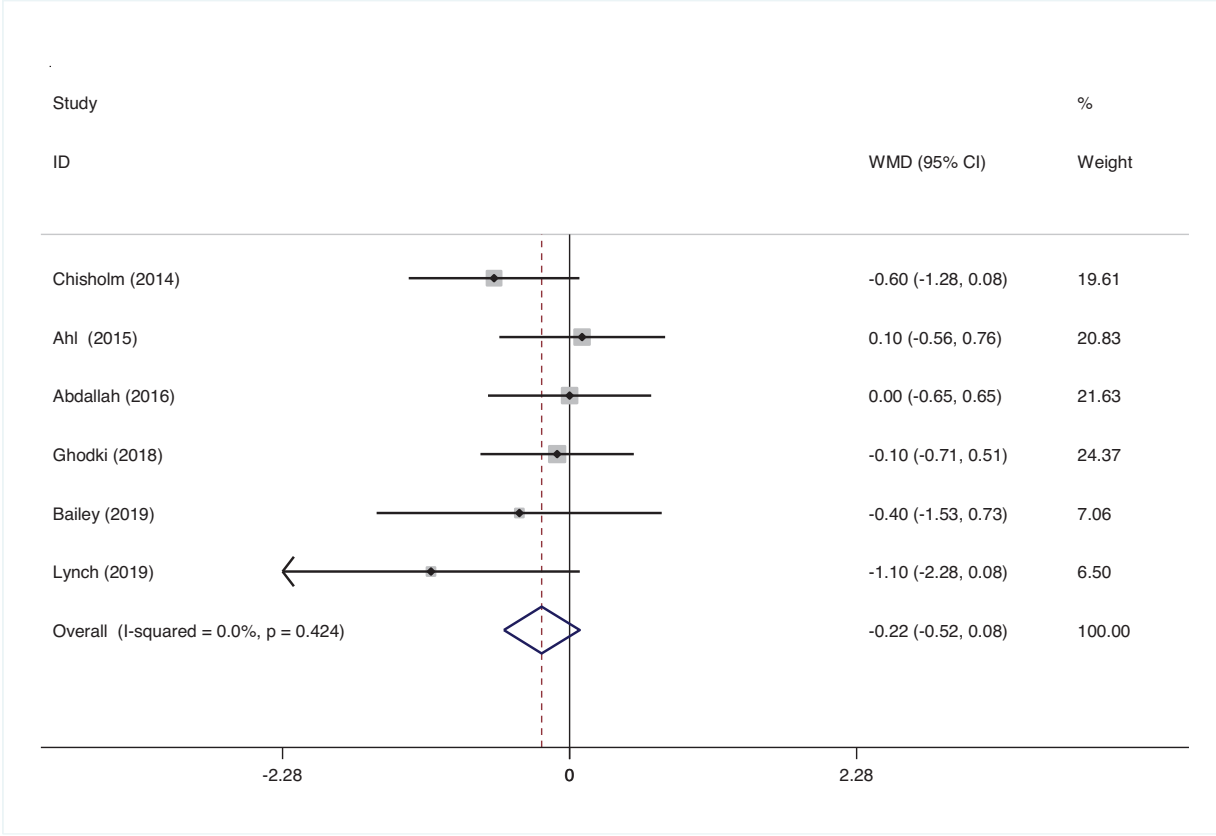

Figure 4. Forest plots of visual analog scale at 6hours.

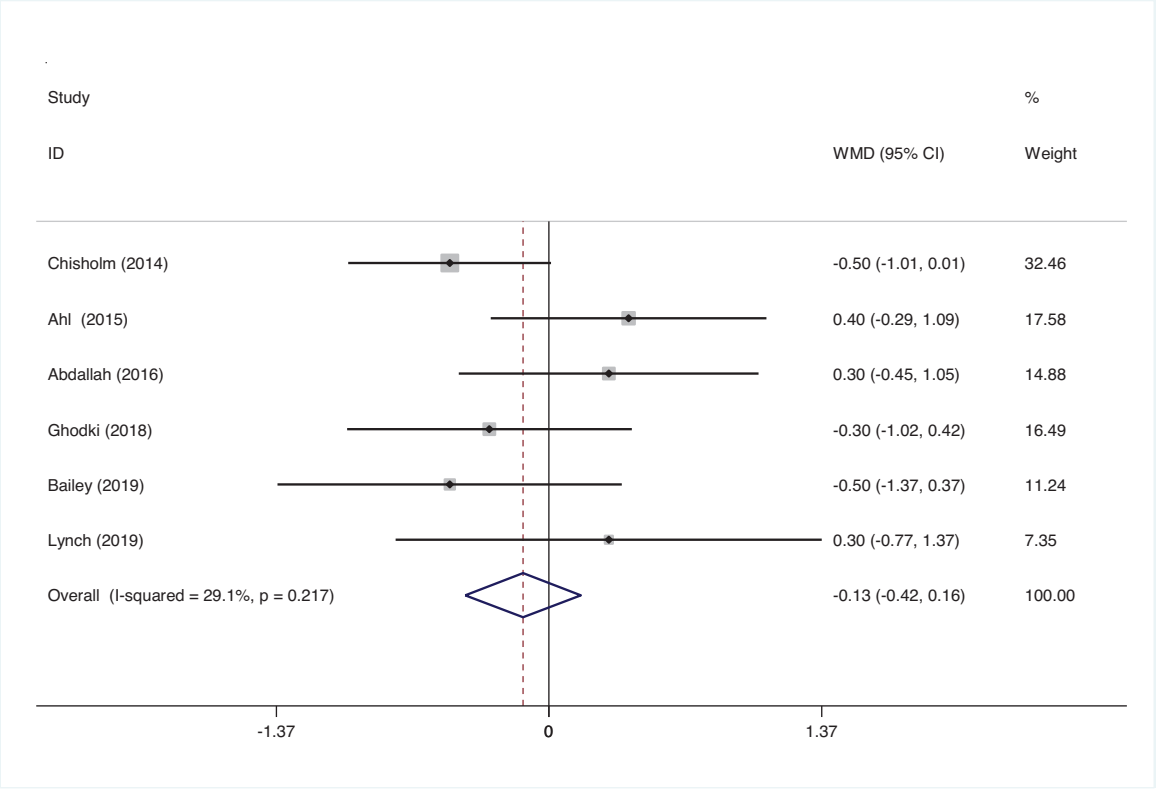

Figure 5. Forest plots of visual analog scale at 12 hours.

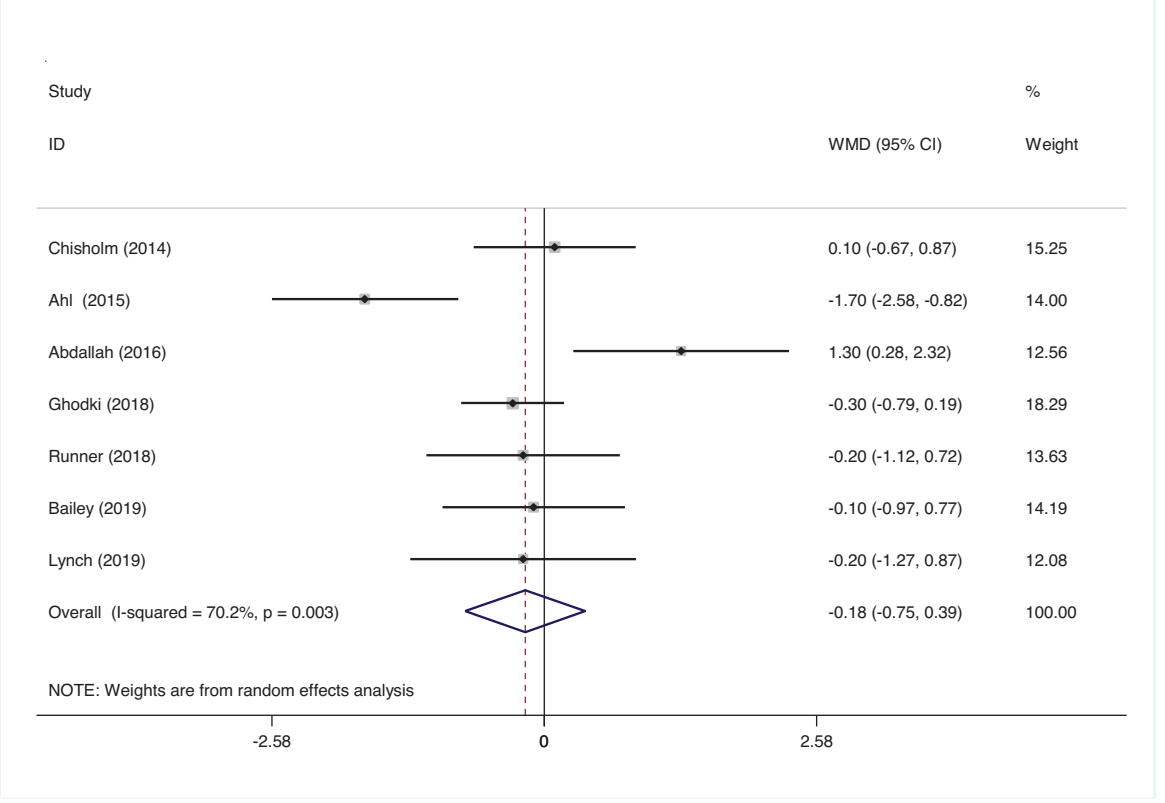

Figure 6. Forest plots of visual analog scale at 24 hours.

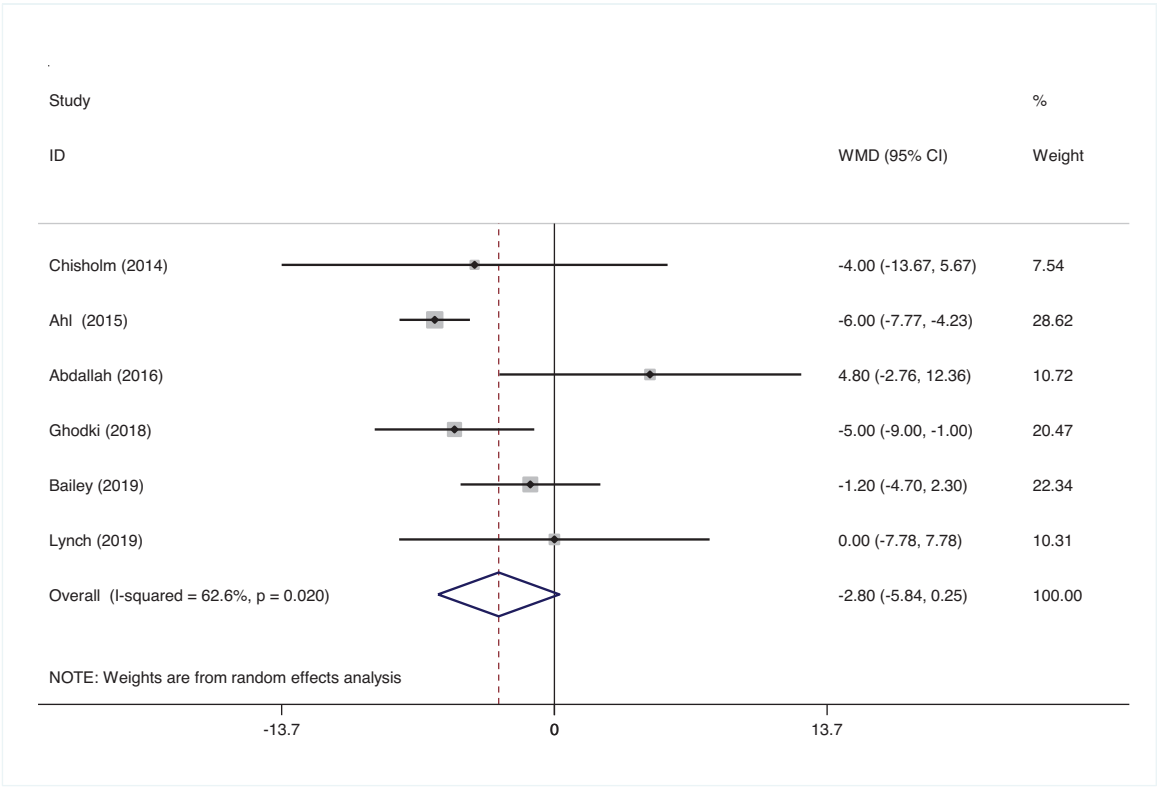

Figure 7. Forest plots of morphine consumption at 24 hours.

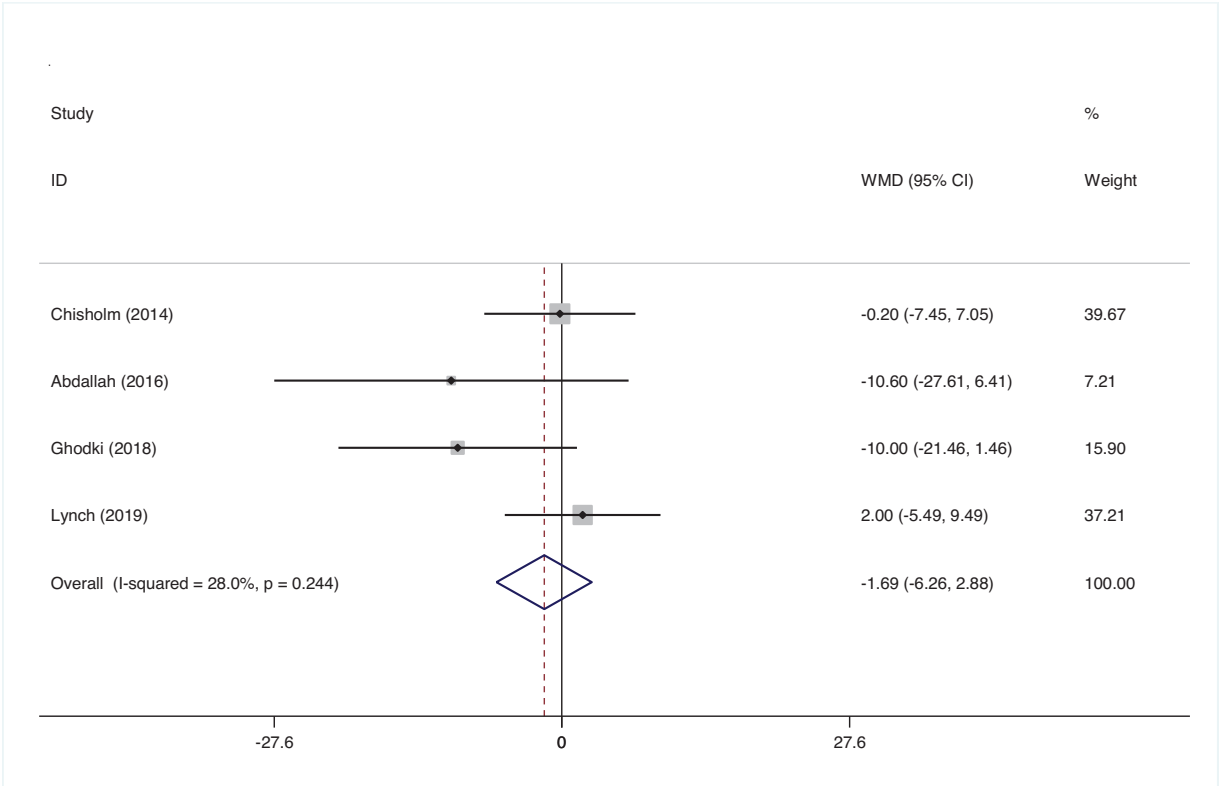

Figure 8. Forest plots of morphine consumption at 48 hours.

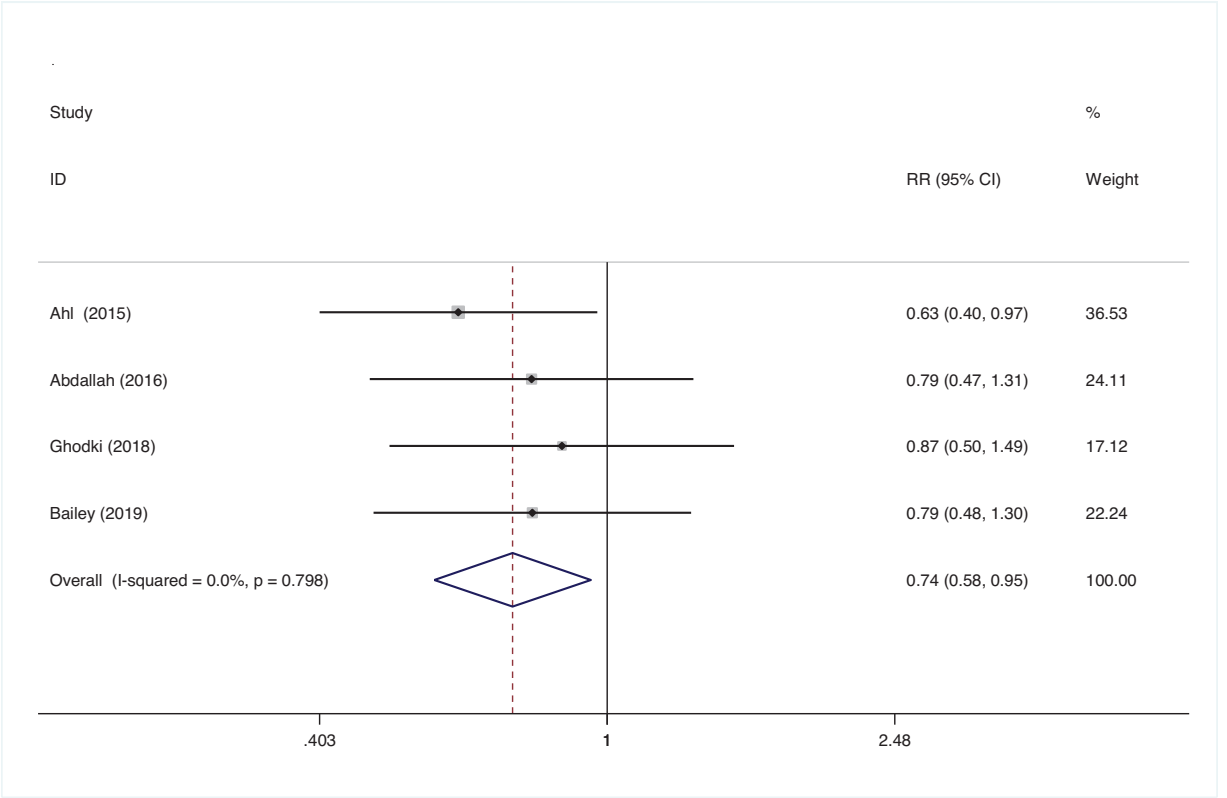

Figure 9. Forest plots of muscle strength of lower limb.

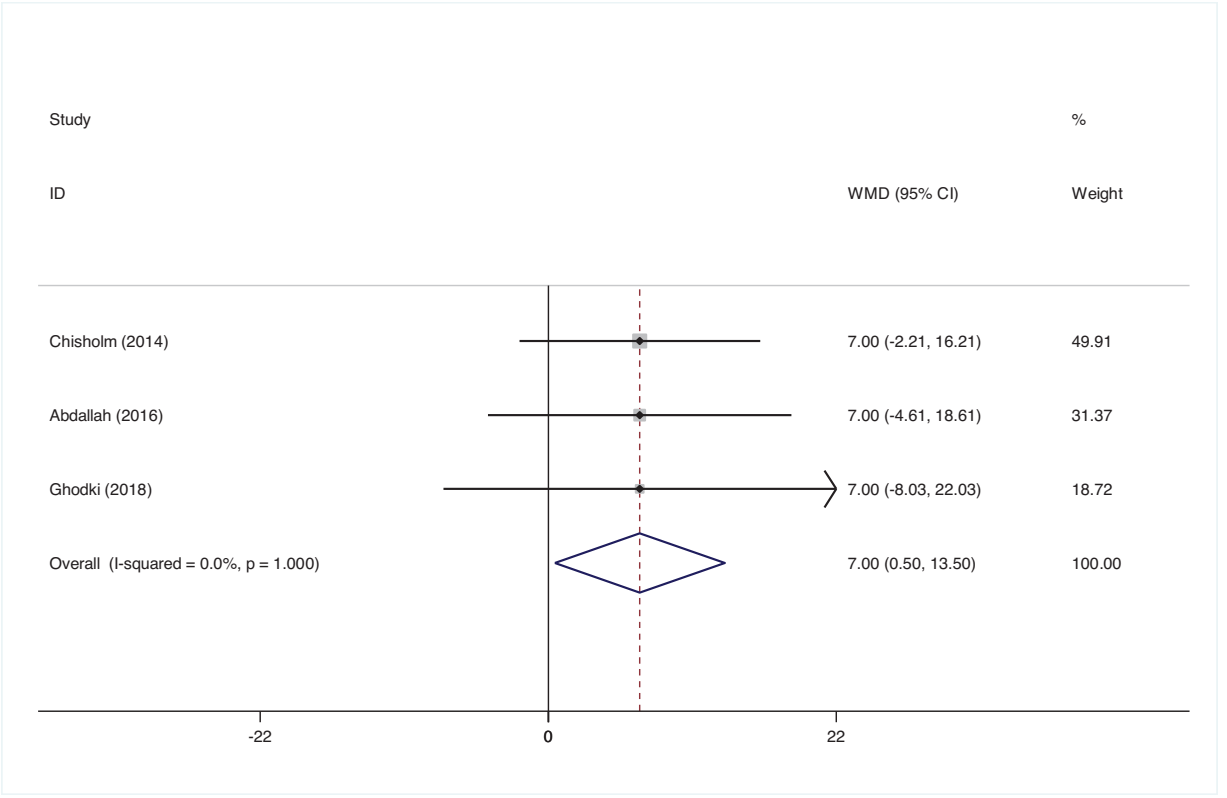

Figure 10. Forest plots of range of motion.

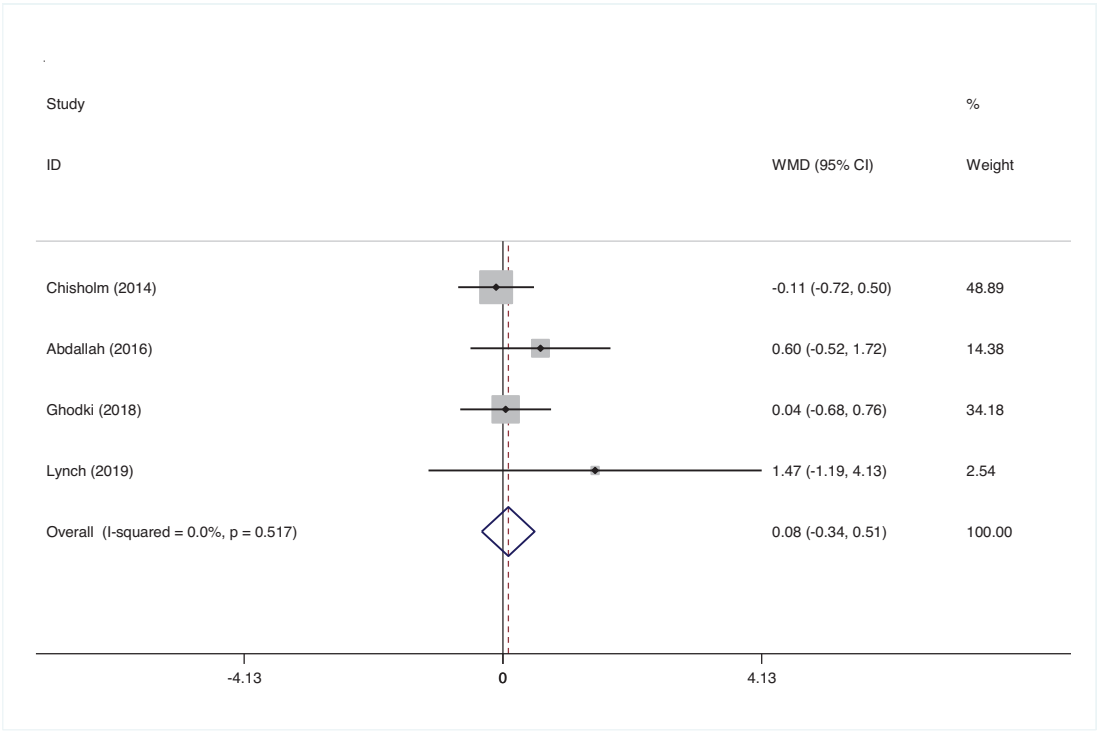

Figure 11. Forest plots of patient satisfaction.

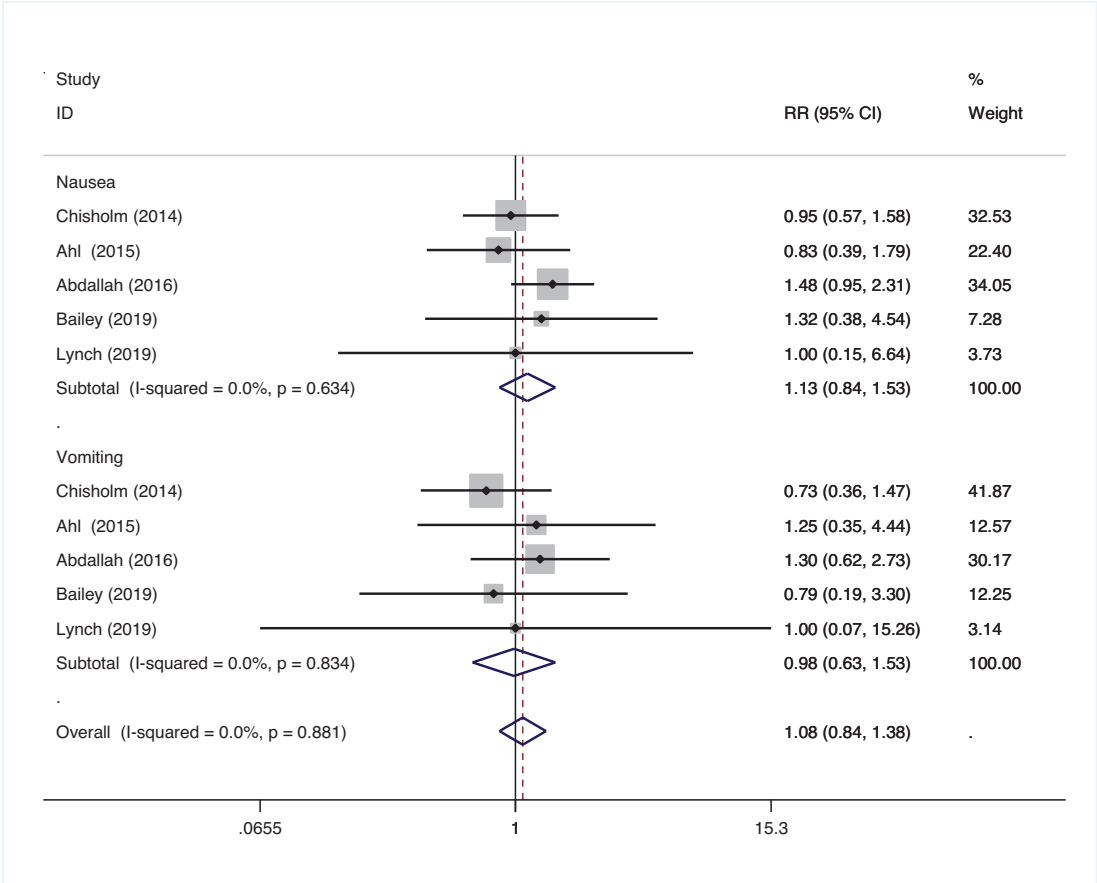

Figure 12. Forest plots of postoperative complications.

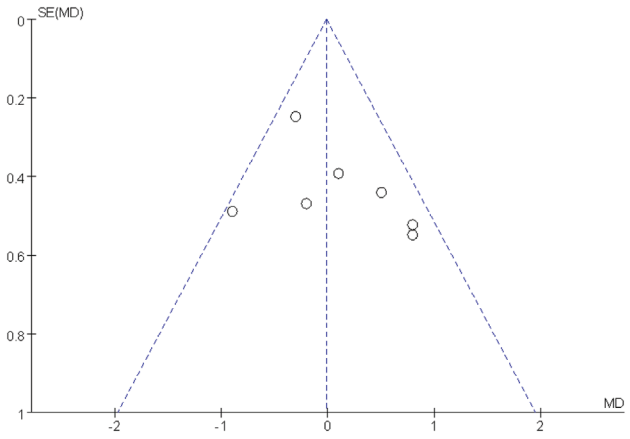

Figure 13. Publication bias.

research is very likely to have an important impact on confidence in the estimate of effect and is likely to change the estimate.

4. Discussion

To the best of our knowledge, this was the first meta-analysis of recent published RCTs to compare the effectiveness and safety between FNB and ACB for postoperative pain management after ACL reconstruction. The most interesting finding of the present review was that both FNB and ACB showed equally effective in reducing pain and morphine consumption after ACL reconstruction. There were no obvious differences between the 2 groups with regards to patient satisfaction or postoperative adverse events. Furthermore, ACB showed superior quadriceps strength and range of motion.

ACL tear is a common orthopedic injury with an incidence of 69/100,000 per year. ACL reconstruction has been widely accepted as the treatment of choice for knee functional disorder due to ACL tear. The number of ACL reconstructions performed is estimated to be 130 thousand each year in the United States.[20] Considering the continuously increasing number of ACL reconstruction being performed, establishing a satisfactory postoperative pain management has become essential. Failure to provide effective pain management may increase morbidity, delay recovery and impair quality of life. It is necessary to have an effective analgesic protocol for optimal patient satisfaction and outcome. FNB is a well-established treatment and by many considered as the criterion standard. Magnussen et al[21] reported that the performance of FNB resulted in an improved postoperative analgesia. However, motor blockade of the quadriceps muscle may potentially delay postoperative mobilization, as well as increase the risk of falls. Luo et al[22] reported that quadriceps muscle weakness persisted for up to 6 months after ACL reconstruction using FNB for pain management. ACB has been proposed an attractive alternative to FNB as the peripheral nerve block. It plays an important role in preserving the strength of the quadriceps femoris muscle as well as providing pain relief to the knee which is comparable to FNB.[23] However, the efficacy and safety of ACB remains controversial, as articles have reported less adequate analgesia or no change in quadriceps muscle strength. The primary outcome evaluated in our study was the VAS score at different periods. The present meta-analysis indicated that there were no significant differences between ACB groups and FNB groups regarding the VAS score at 6 hours, 12 hours, or 24 hours after ACL reconstruction.

Morphine is the most frequently used agents for postoperative pain management as it is extremely effective both in short- and long-acting formulations. The mechanism is to bind and activate the receptors in both the central and peripheral nervous systems and intravenous patient-controlled analgesia is the most popular delivery method.[24] Although morphine is effective in relieving moderate to severe pain, use of opioid is associated with side effects including nausea, vomiting, headache, pruritus, urinary

Table 2

Quality of the evidence.

Outcomes	No. of RCTs	Inconsistency	Indirectness	Imprecision	Limitations	Effect	Quality	Importance
VAS score at 6 hr	6	Serious	None serious	None serious	Serious	WMD= −0.221; 95% CI: −0.522 to 0.080	Low	Critical
VAS score at 12 hr	6	Serious	None serious	None serious	Serious	WMD = −0.131; 95% CI: −0.421 to 0.160	Low	Critical
VAS score at 24 hr	7	Serious	None serious	None serious	Serious	WMD= −0.180; 95% CI: −0.749 to 0.389	Low	Critical
Morphine consumption at 24 hr	6	Serious	None serious	None serious	Serious	WMD = −2.796; 95% CI: −5.840 to 0.248	Low	Important
Morphine consumption at 48 hr	4	Serious	None serious	None serious	Serious	WMD = −1.689; 95% CI = −6.258 to 2.879	Low	Important
Muscle strength of lower limb	4	None Serious	None serious	None serious	Serious	RR = 0.742; 95% CI = 0.580 to 0.950	Moderate	Important
Patient satisfaction	4	Serious	None serious	None serious	Serious	WMD = 0.084; 95% CI = −0.340 to 0.507	Low	Important
Length of hospitalization	4	Serious	None serious	None serious	Serious	WMD= 0.046; 95% CI: −0.239 to 0.331	Low	Important
Incidence of nausea and vomiting	5	Serious	None serious	None serious	Serious	RR = 1.078, 95% CI: 0.842 to 1.380	Low	Important

CI = confidence interval, RR = risk ratio, VAS = visual analogue scale, WMD = weighted mean difference.

retention and drug abuse,[25,26] which impedes functional rehabilitation, increases the length of hospitalization and risk of postoperative complications. Adequate pain management can significantly reduce morphine consumption and it is also considered a reasonable indicator for assessing the analgesic effect. Current evidence of the opioid-sparing effect comparing ACB and FNB remains under debate. Bailey et al[18] indicated that the 2 groups consumed a similar amount of opioids after ACL reconstruction. Ahl et al[14] found that patients in group ACB had significantly higher morphine consumption than that in group FNB. In our study, 6 RCTs calculated opioid consumption and there was no significant difference in opioid requirement between the 2 groups, which indirectly verified the aforementioned outcomes of pain scores.

Early initiation of strength and activation training of the quadriceps is an important component of successful rehabilitation protocols after ACL reconstruction. Quadriceps strength preservation has been associated with improved functional performance and higher rates of return to sport. In addition to the concerns regarding incomplete recovery, postoperative quadriceps strength deficits have been associated with gait abnormalities and subsequent development of posttraumatic osteoarthritis. Kwofie et al[27] indicated that both ACB and FNB reduced lower limb strength compared with baseline. Jaeger et al[28] reported that the reduction of quadriceps femoris strength from baseline was 45% with FNB but only 9% with ACB in healthy young subjects. Restoring quadriceps muscle function is key to safely returning patients to sport and muscle strength weakness is strongly associated with the subsequent risk of ACL reinjury and falls. Bailey et al[18] reported that quadriceps surface electromyography deficits were higher for FNB at 24 hours when compared with the ACB group. Abdallah et al[15] found that patients in the ACB group had superior motor strength at all of the time points. Our meta-analysis indicated that ACB was associated with an improved muscle strength of lower limb compared with FNB. Further examination is required to explore the underlying mechanisms and potential long-term effects of these interventions.

The strength of our study is that all the included studies were RCTs and most of the outcomes measure were low heterogeneity which can provide reliable evidence. The present study should be interpreted in light of its limitations. First, only seven RCTs involving a total of 643 patients were included in our meta-analysis, which may affect the results. Second, heterogeneity among the included RCTs was unavoidable due to the different regimens applied for groups. Heterogeneity was also caused by several factors, such as racial and age differences. Third, the surgical approach and graft choice were not reported in included studies and varying approaches may influence the results, particularly with regard to quadriceps strength after quadriceps or patellar tendon harvest. Additionally, the included studies also reported different volumes and concentrations of ropivacaine for nerve blockade which introduces heterogeneity between studies. Finally, suture method and suture materials can also affect the postoperative pain,[29–32] subgroup analysis regarding this issue should be performed in the future.

5. Conclusion

ACB shows similar and adequate analgesia compared to the FNB in ACL reconstruction and ACB can preserve a higher quadriceps strength and better range of motion.

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