

## REVIEW ARTICLE

# Analgesic Efficacy of Adductor Canal Block in Total Knee Arthroplasty: A Meta-analysis and Systematic Review

Xu Jiang, MD<sup>1</sup>, Qian-qian Wang, MD<sup>2</sup>, Cheng-ai Wu, MD<sup>2</sup>, Wei Tian, MD<sup>1</sup>

<sup>1</sup>Department of Orthopaedics, Beijing Jishuitan Hospital, The Fourth Clinical Medical College of Peking University and <sup>2</sup>Department of Molecular Orthopaedics, Beijing Institute of Traumatology and Orthopaedics, Beijing, China

The aim of this meta-analysis and systematic review of randomized controlled trials (RCTs) was to evaluate the efficacy and safety of adductor canal block (ACB) for early postoperative pain management in patients undergoing total knee arthroplasty (TKA). Relevant manuscripts comparing ACB with saline or femoral nerve block (FNB) in TKA patients were searched for in the databases of PubMed, EMBASE, and Cochrane library. The outcomes assessed included cumulative analgesic consumption, pain at rest or during movement, ability to ambulate, quadriceps strength, and complications (nausea, vomiting or sedation). For continuous outcomes, pooled effects were measured using weighted mean difference (WMD) or standard mean difference (SMD), together with 95% confidence intervals (CIs). For outcomes without sufficient data for synthesis, qualitative interpretation of individual studies was summarized. Finally, 11 RCTs involving 675 patients met the inclusion criteria. The pooled results showed that ACB resulted in less postoperative analgesic consumption than saline (WMD, -12.84 mg; 95% CI, -19.40 mg to -6.27 mg;  $P < 0.001$ ) and less pain at rest or during activity. No conclusions could be drawn regarding ability to ambulate and quadriceps strength, because only one study reported these variables. Most studies comparing ACB and FNB reported similar effects on postoperative analgesic consumption (WMD, -0.56 mg; 95% CI, -8.05 mg to 6.93 mg;  $P = 0.884$ ) and pain; however, ability to ambulate and quadriceps strength were significantly better with ACB (SMD, 0.99; 95% CI, 0.04–1.94;  $P = 0.041$ ). Additionally, ACB did not increase the rate of complications. Our results suggest that, compared with saline, ACB decreases analgesic consumption and offers short-term advantages in terms of pain relief. Compared with FNB, ACB was associated with better ability to ambulate and quadriceps strength.

**Key words:** Adductor canal block; Analgesia; Meta analysis; Randomized controlled trials; Total knee arthroplasty

## Introduction

Total knee arthroplasty (TKA) is a successful intervention for patients with painful degenerative diseases affecting the knee joint. The management of pain after TKA has always been a key focus in the clinical treatment of patients undergoing this procedure. Postoperative pain leads to decreased ability to mobilize the knee, prolonged hospitalization and increased complications. Despite comprehensive multimodal analgesic regimens, this problem has not been successfully addressed. Peripheral nerve blocks are increasingly preferred to relieve postoperative pain and to reduce opioid consumption and opioid-related adverse effects in patients undergoing orthopedic procedures. Femoral nerve

block (FNB) has been one of the most commonly used peripheral nerve blocks for managing post-TKA pain. Compared with epidural or intravenous patient-controlled analgesia alone, addition of FNB to an analgesic regimen provides superior pain control, reduces the incidence of postoperative complications and shortens the time to functional recovery<sup>1,2</sup>. Nevertheless, since FNB targets the femoral nerve, which comprises both sensory and motor branches, it often weakens the quadriceps muscle, resulting in delayed mobilization and an increasing risk of falling<sup>3,4</sup>.

Adductor canal block (ACB) is a relatively new type of peripheral nerve block technique introduced by Lund *et al.*<sup>5</sup>. It offers better patient management after TKA than FNB<sup>5</sup>.

**Address for Correspondence** Wei Tian, MD, Department of Orthopaedics, Beijing Jishuitan Hospital, The 4th Clinical Medical College of Peking University, Beijing, China 100035 Tel: 0086-013911807034; Fax: 0086-10-58516538; Email: wuchengai05@163.com

**Disclosure:** The study was supported by the National Natural Science Foundation of China (No. 81330043; 81472139) and the Projects in the National Science & Technology Pillar Program during the Twelfth Five-year Plan Period (No. 2012BAI10B02).

Received 2 April 2016; accepted 5 May 2016

ACB affects not only the two largest sensory contributors from the femoral nerve to the knee, namely, the saphenous nerve and the branch to the vastus medialis, but also the articular branches of the obturator nerve. However, the block is distal to most of the efferent branches to the quadriceps muscle and therefore largely preserves the strength of this muscle<sup>6,7</sup>.

The efficacy of ACB compared with saline or FNB has been evaluated in several randomized controlled trials (RCTs), the results of which are controversial, being confounded by wide variations in study design. Dixit *et al.* examined the efficacy of ACB for all types of knee surgeries based on evidence obtained from 2000 to 2013 and obtained consistent results; the consistency of their results was attributable to the small sample size (only 289 patients) or the presence of bias<sup>8</sup>. Since their study, several new RCTs on this issue have been published, providing more evidence. We have therefore performed an updated systematic search and review of the available RCTs to assess the analgesic efficacy and safety of ACB for pain management after TKA.

## Materials and Methods

### Search Strategy

The databases of PubMed, Embase, and the Cochrane Library were searched using predefined search terms related to intervention (“adductor canal block” OR “adductor-canal-blockade” OR “ACB”) and operation type (“knee arthroplasty” OR “knee replacement” OR “Arthroplasty, Replacement, Knee”[Mesh]) for articles published from inception to February 2015, without any language restrictions. Additionally, the references of the included studies and pertinent systematic reviews were screened manually. Two authors (Jiang X and Wu CA) independently reviewed the titles and full texts of the relevant studies. Disagreements were resolved through discussion.

### Inclusion and Exclusion Criteria

The inclusion criteria were (i) RCTs comparing ACB with FNB or a placebo; (ii) original studies conducted on TKA patients; and (iii) studies reporting at least one of the following outcomes: cumulative postoperative analgesic consumption, pain scores on a visual analog scale (VAS) or numeric rating scale (NRS) at rest or during 45° knee flexion, ability to mobilize, quadriceps muscle strength, opioid-related adverse effects such as nausea, vomiting, and sedation and the success rate of the block. In the case of overlapping studies, the latest and/or most informative study was included. Exclusion criteria were defined as follows: (i) duplicate publications; (ii) studies with insufficiently reported data.

### Data Extraction

The following items were extracted from each study: author details, publication year, study design, size of each group, characteristics of study subjects, type of intervention, type of systemic analgesia, pain at rest or during activity, opioid

consumption in the early postoperative period and other outcomes. Data extraction was performed independently by two reviewers. Any discrepancies were resolved by discussion.

### Quality Assessment

Risk of bias in individual studies was assessed based on the seven items in the Cochrane handbook; namely, random sequence generation, allocation concealment, blinding of participants or outcome assessors, incomplete outcome data, selective reporting and other bias<sup>9</sup>. Each item was recorded as “Yes,” “No,” or “Unclear.” “Yes” indicates a high risk of bias and “No” a low risk of bias. “Unclear” indicates a lack of information or an unknown risk of bias.

### Statistical Analysis

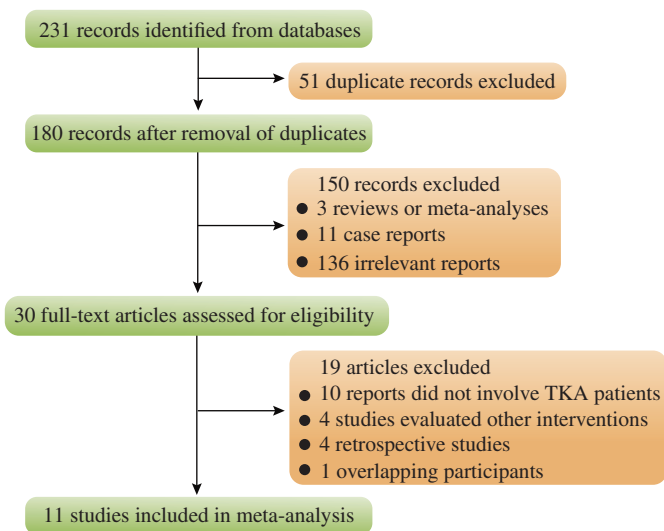
In the case of outcomes for which the included studies provided sufficient quantitative data, weighted mean difference (WMD) or standard mean difference (SMD) and 95% confidence intervals (CIs) were used to estimate the overall effect. Evidence of statistically significant heterogeneity was assessed using the *Q* statistic, whereas the extent of observed heterogeneity was assessed using the *I*<sup>2</sup> statistic (ranging from 0% to 100%)<sup>10</sup>. In the absence of between-study heterogeneity (*I*<sup>2</sup> ≤ 50%), the fixed-effect model was used for data analyses. Otherwise, the random-effect model was used. Publication bias was assessed with the Egger test<sup>11</sup>. Other outcomes such as pain at rest or during knee flexion and morphine-related adverse effects were summarized using qualitative interpretations of the individual study methods and results because of variations in the time points and methods of measurements among the studies. All analyses were performed using Stata 9.0 (Stata Corp, College Station TX, USA). Statistical significance was assumed at a *P* value threshold of 0.05.

## Results

The database searches identified 231 articles, of which 11 met the inclusion criteria and were used for qualitative and quantitative synthesis<sup>12–22</sup>. Details of the process for screening published reports are shown in a flow chart (Fig. 1).

### Study Characteristics

All 11 studies (involving 675 patients who underwent TKA) included for review were RCTs. The characteristics of these studies are summarized in Table 1. In brief, the control treatment was saline in four studies<sup>12,13,15,17</sup>, FNB in six studies<sup>14,18–22</sup> and sham catheterization in one study<sup>16</sup>. For data analysis, we categorized the study with sham catheterization and the group of studies that used saline as including placebo treatment. Two studies examined the primary outcome soon after the operation (within 2 h of surgery)<sup>15,22</sup>, whereas the other studies assessed it longer after TKA (6–48 h postoperatively)<sup>12–14,16–21</sup>. Ropivacaine was used as an anesthetic in the intervention group in nine studies<sup>12–17,20–22</sup> and bupivacaine in the other two



**Fig. 1** Flow chart showing selection of studies.

studies<sup>18–19</sup>. Nine studies used a VAS to evaluate pain<sup>12–15,17,19–22</sup>, whereas the other two studies used an 11-point NRS<sup>16,18</sup>. TKA was performed under spinal anesthesia in eight studies<sup>13–15,18–22</sup> and under general anesthesia in two<sup>12,17</sup>. The type of anesthesia was not mentioned in the remaining study<sup>16</sup>. The studies' sample sizes ranged from 36 to 100 and the mean age of the study subjects from 34 to 71 years (Table 1).

The primary or secondary outcomes assessed in the studies included pain at rest and on mobilization, cumulative opioid consumption, quadriceps muscle strength and morphine-related adverse effects and were measured at different time points after the operation. The risk of bias of the included studies is shown in Table 2. We considered that five trials had a low risk of bias<sup>12–14,16,17</sup>. In the remaining six studies, the risk of bias was unclear because of incomplete blinding or inadequate concealment of allocation (Table 2)<sup>15,18–22</sup>.

### Narcotic Consumption

Six RCTs, including 361 participants, reported the consumption of analgesics after surgery<sup>12–14,16–18</sup>. An analysis of their results showed that ACB was associated with less analgesic consumption (WMD,  $-7.50$  mg; 95% CI,  $-12.44$  mg to  $2.56$  mg;  $P < 0.003$ ). There was no significant heterogeneity among the studies. We performed subgroup analyses by different control groups. Pooled results from the ACB versus saline groups showed that ACB significantly decreased postoperative analgesic consumption (WMD,  $-12.84$  mg; 95% CI,  $-19.40$  mg to  $6.27$  mg;  $P < 0.001$ ). However, the difference between ACB and FNB in postoperative analgesic consumption was not statistically significant (WMD,  $-0.56$  mg; 95% CI,  $-8.05$  mg to  $6.93$  mg;  $P = 0.884$ ; Fig. 2).

For the sensitivity analysis, we evaluated the effect of excluding a study that included patients undergoing revision

TKA; this did not materially change the results (data not shown)<sup>17</sup>. The Egger test for assessment of publication bias showed no statistically significant asymmetry ( $P = 0.636$ ).

### Pain at Rest and during Movement

Five randomized trials, including 283 subjects, compared the intensity of pain at rest between the ACB group and saline or no injection groups at different postoperative time points<sup>12,13,15–17</sup>. Compared with the control saline treatment or no intervention, ACB was associated with lower pain scores in the early postoperative period in all five studies; however, these differences were not statistically significant. The evidence from six RCTs indicated that ACB was not associated with more pain at rest than FNB<sup>14,18–22</sup> (Table 3).

Five randomized trials reported a difference in pain intensity during 45° flexion of the knee between the ACB and placebo groups<sup>12,13,15–17</sup>. ACB was associated with lower pain scores than placebo in the early postoperative period. However, the severity of pain during activity did not differ significantly between the ACB and FNB groups<sup>14,18–22</sup> (Table 3).

### Other Outcomes

Ability to ambulate, as assessed by the timed up and go (TUG) test, was reported in four RCTs<sup>13,14,20,22</sup>. The results from these studies showed that ability to ambulate was significantly better in the ACB than in the control group.

Quadriceps strength was assessed in six studies<sup>14,16,18,19,21,22</sup>, five of which compared quadriceps strength in the ACB group with that in the FNB group<sup>14,18,19,21,22</sup>. Because these five studies used different measures and different units, we synthesized the data from them using the standard mean difference (SMD). The pooled results from the five studies suggested that ACB was associated with greater quadriceps strength than FNB (SMD, 0.99; 95% CI, 0.04–1.94, random-effect model;  $P = 0.041$ ; Fig. 3).

No increase in the rate of nausea, vomiting or sedation was found in the ACB group in any of the included studies. Rather, Jaeger *et al.* reported that patients in the ACB group experienced significantly less nausea than those in the saline group<sup>12</sup>. Seven studies investigated the success rate of the block, which varied from 93.6% to 100% (Table 3).

### Discussion

The present study summarizes the available evidence for the analgesic efficacy of ACB compared with saline administration, no injection or FNB. The pooled results show that ACB was associated with significantly less postoperative analgesic consumption than saline. In addition, ACB seemed to be associated with less pain at rest and during activity; however, these differences were not statistically significant. We were unable to reach a conclusion regarding the effects of ACB on ability to ambulate and quadriceps strength because only one study explored these issues. However, all the above findings indicate that provision of

TABLE 1 Characteristics of the included studies

Study	Time points	Country	Anesthesia	Interventions		Pain scale	Sample size (M/F, cases)		Mean age (ACB/control, years)
				ACB	Control		ACB	Control	
Jæger <i>et al.</i> (2012) <sup>12</sup>	0.5, 1, 2, 3, 4, 5, 6 h	Denmark	General anesthesia	0.75% ropivacaine, 30 mL	Saline, 30 mL	VAS	21 (12/9)	20 (11/9)	66/69
Jenstrup <i>et al.</i> (2012) <sup>13</sup>	2, 4, 8, 24, 26 h	Denmark	Spinal anesthesia	0.75% ropivacaine as a 30 mL bolus and additional 15 mL boluses at 6, 12, and 18 h postoperatively	Saline as a 30 mL bolus and additional 15 mL boluses at 6, 12 and 18 h postoperatively	VAS	34 (18/16)	37 (19/18)	67/67
Jæger <i>et al.</i> (2013) <sup>14</sup>	2, 4, 8, 24 h	Denmark	Spinal anesthesia	ACB with 30 mL bolus of 0.5% ropivacaine, followed by 0.2% ropivacaine infusion (8 mL/h) over the next 24 h	FNB with 30 mL bolus of 0.5% ropivacaine via a catheter, followed by 0.2% ropivacaine infusion (8 mL/h) over the next 24 h	VAS	23 (5/18)	27 (14/13)	70/66
Grevstad <i>et al.</i> (2014) <sup>15</sup>	15, 30, 45, 60, 75, 90 min	Denmark	Spinal anesthesia	ACB with 0.75% ropivacaine (30 mL) at 0 h and 30 mL isotonic saline at 45 min	Saline (30 mL) at 0 h, 0.75% ropivacaine (30 mL, ACB) at 45 min	VAS	24 (5/19)	25 (7/18)	67/71
Hanson <i>et al.</i> (2014) <sup>16</sup>	6, 12, 18, 24, 30, 36, 42, 48 h	USA	-	Continuous ultrasound-guided ACB with 0.2% ropivacaine at 8 mL/h with a 400-mL reservoir	Continuous ultrasound-guided ACB with sham catheter	NRS	36 (11/25)	40 (15/25)	67/70
Jenstrup <i>et al.</i> (2014) <sup>17</sup>	1, 2, 4, 6, 8, 24 h	Denmark	General anesthesia	ACB with ropivacaine for 24 h: 30 mL bolus of 0.75% ropivacaine, 15 mL bolus after 6 h, then 0.2% ropivacaine infusion (8 mL/h)	ACB with saline for 24 h: 30 mL saline bolus and 15 mL saline bolus after 6 h followed by saline infusion (8 mL/h)	VAS	14 (8/6)	16 (8/8)	65/67
Kim <i>et al.</i> (2014) <sup>18</sup>	6-8, 24, 48 h	USA	Spinal anesthesia	ACB with 0.5% bupivacaine (15 mL) and 5 µg/mL epinephrine	FNB with 0.25% bupivacaine (30 mL) and 5 µg/mL epinephrine	NRS	46 (22/24)	47 (18/29)	68/67.6
Memtsoudis <i>et al.</i> (2014) <sup>19</sup>	6-8, 24, 48 h	USA	Spinal anesthesia	ACB with 0.25% bupivacaine (15 mL)	FNB with 0.25% bupivacaine (30 mL)	VAS	30 (26/33)	29	64.41
Shah <i>et al.</i> (2014) <sup>20</sup>	4, 8, 12, 24 h	India	Spinal anesthesia	ACB with 0.75% ropivacaine (30 mL) and 30 mL boluses of 0.25% ropivacaine at 4 h intervals till 8:00 am on the second day after surgery	FNB with 0.75% ropivacaine (30 mL) and 30 mL boluses of 0.25% ropivacaine at 4 h intervals till 8:00 am on the second day after surgery	VAS	48 (13/35)	50 (14/36)	68.3/65.9
Zhang <i>et al.</i> (2014) <sup>21</sup>	4, 24, 48 h	China	Spinal anesthesia	ACB with 0.33% ropivacaine (20 mL)	FNB with 0.33% ropivacaine (20 mL)	VAS	30 (6/24)	30 (8/22)	63.7/61.9
Grevstad <i>et al.</i> (2014) <sup>22</sup>	0, 30, 60, 90, 120 min	Denmark	Spinal anesthesia	"ACB" box contained 3 x 10 mL containers of 0.2% ropivacaine; "FNB" box contained 3 x 10 mL containers of isotonic saline	"ACB" box contained 3 x 10 mL containers of isotonic saline; "FNB" box contained 3 x 10 mL containers of 0.2% ropivacaine	VAS	25 (7/18)	25 (8/17)	65/64

ACB, adductor canal block; FNB, femoral nerve block; M/F, number of males/number of females; MVIC, maximum voluntary isometric contraction; NRS, numeric rating scale; VAS, visual analogue scale.

TABLE 2 Risk of bias in the included studies

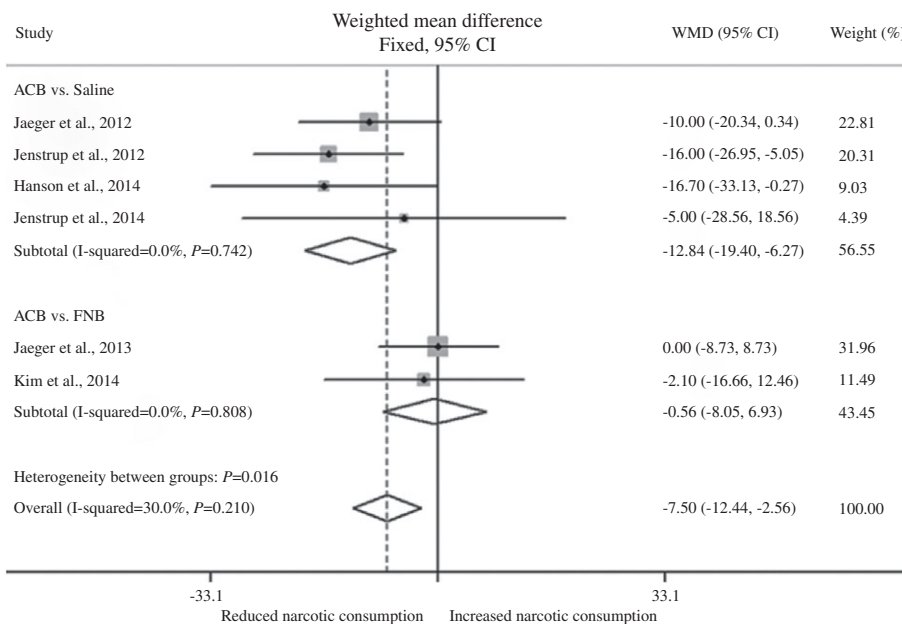
Study	Adequate sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias (similar systemic analgesia)
Jæger <i>et al.</i> (2012) <sup>12</sup>	+	+	+	+	+	+	+
Jenstrup <i>et al.</i> (2012) <sup>13</sup>	+	+	+	+	+	+	+
Jæger <i>et al.</i> (2013) <sup>14</sup>	+	+	+	+	+	+	+
Grevstad <i>et al.</i> (2014) <sup>15</sup>	?	+	?	?	+	+	+
Hanson <i>et al.</i> (2014) <sup>16</sup>	+	+	+	+	+	+	+
Jenstrup <i>et al.</i> (2014) <sup>17</sup>	+	+	+	+	+	+	+
Kim <i>et al.</i> (2014) <sup>18</sup>	+	+	+	?	+	+	+
Memtsoudis <i>et al.</i> (2014) <sup>19</sup>	?	+	+	+	+	+	+
Shah <i>et al.</i> (2014) <sup>20</sup>	+	?	+	+	+	+	+
Zhang <i>et al.</i> (2014) <sup>21</sup>	?	?	?	?	+	+	+
Grevstad <i>et al.</i> (2014) <sup>22</sup>	+	+	?	?	+	+	+

+ , yes; ? , unclear.

analgesia by ACB after TKA may offer some short-term benefits over saline treatment or no intervention.

Most of the studies comparing ACB and FNB reported similar effects of the two blocks on postoperative analgesic

consumption and pain scores. However, there was a statistically significant difference in favor of ACB for ability to ambulate and quadriceps strength. FNB is often used as a standard analgesic treatment after knee surgery<sup>23</sup>; however, it

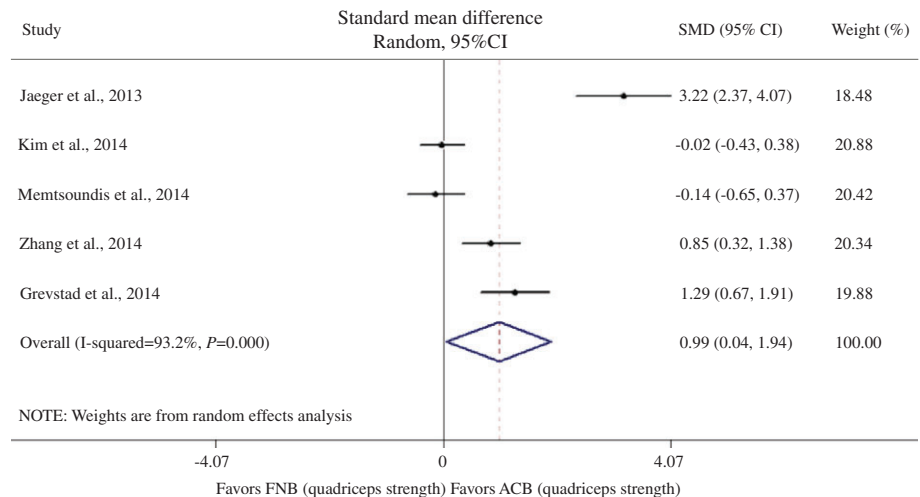


**Fig. 2** Forest plot showing relationship of different analgesic treatments with cumulative narcotic consumption after TKA. The diamonds indicate the overall effect as calculated using the weighted mean difference (WMD) in a fixed-effect model.

**TABLE 3** Summary of the results of the included studies investigating the analgesic efficacy of ACB for TKA

Study	Control treatment	Pain at rest	Pain during flexion	TUG test	Quadriceps muscle strength	Adverse effects	Success rate of ACB
Jæger <i>et al.</i> (2012) <sup>12</sup>	Saline	-NS	-	-	NR	NS	95%
Jenstrup <i>et al.</i> (2012) <sup>13</sup>	Saline	-NS	-	-NS	NR	NS	94%
Jæger <i>et al.</i> (2013) <sup>14</sup>	FNB	-NS	-NS	NR	-	NS	NR
Grevstad <i>et al.</i> (2014) <sup>15</sup>	Saline	-	-	NR	NR	NR	98%
Hanson <i>et al.</i> (2014) <sup>16</sup>	Sham catheter	-NS	-	NR	-	NS	NR
Jenstrup <i>et al.</i> (2014) <sup>17</sup>	Saline	-NS	-	NR	NR	NS	NR
Kim <i>et al.</i> (2014) <sup>18</sup>	FNB	+NS	NR	NR	-	NS	98%
Memtsoudis <i>et al.</i> (2014) <sup>19</sup>	FNB	+NS	+NS	NR	+NS	NR	NR
Shah <i>et al.</i> (2014) <sup>20</sup>	FNB	-NS	-NS	-	NR	NS	96%
Zhang <i>et al.</i> (2014) <sup>21</sup>	FNB	NS	NS	NR	-	NS	NR
Grevstad <i>et al.</i> (2014) <sup>22</sup>	FNB	+NS	-NS	-	-	NR	100%

-, results in favor of ACB and the difference is statistically significant; -NS, results in favor of ACB but the difference is not statistically significant; +NS, results in favor of the control group but the difference is not statistically significant; FNB, femoral nerve block; NS, the difference is not statistically significant; NR, not reported; TUG, timed-up-and-go test.



**Fig. 3** Forest plot of quadriceps strength and femoral nerve block (FNB) versus adductor canal block (ACB). The diamonds indicate the overall effect as calculated using the standard mean difference (SMD) in a random-effect model.

has been shown to reduce muscle strength, which may result in delayed mobilization and increase the risk of falling<sup>24</sup>. Unlike FNB, ACB is performed distal to the vastus medialis and is associated with less reduction in quadriceps muscle strength. Our pooled results confirmed this point. Furthermore, two studies reported that ACB was associated with greater ability to ambulate than FNB, as determined by the TUG test. Analgesic effects were similar in the ACB and FNB groups. Retrospective studies offer more evidence that the analgesic efficiency of ACB is comparable to that of FNB, and that ACB offers more benefits regarding postoperative ambulation<sup>25-27</sup>. Given all this, it seems that ACB is an attractive alternative to FNB in clinical practice.

The present study is an updated meta-analysis to assess the efficacy and safety of ACB. One systematic review has previously been published on the benefits of ACB in

knee surgery<sup>8</sup>. However, only three trials assessed in that review had investigated ACB for TKA; the primary outcome was opioid consumption in the first 24 h after surgery and no statistically significant differences were identified. The small sample size and potential bias prevented the authors from drawing any firm conclusions about the efficiency of ACB. In comparison, our review contains data from new, larger trials and was restricted to RCTs involving TKA patients. Despite these measures, the evidence we obtained was not strong enough to make definite clinical recommendations. Additionally, certain limitations should be considered. First, the outcomes were measured at different postoperative time points in different studies, and several of them could not be adequately synthesized by the meta-analysis because there were insufficient data; this may have reduced the level of evidence. Therefore, in these



measurements, large scale studies are necessary to draw firm conclusions about the effects of ACB. Secondly, although no statistically significant publication bias was found by the Egger test, we must emphasize that the exclusion of unpublished research may have affected the validity of our findings.

## Conclusions

We found that ACB is associated with significantly less analgesic consumption after TKA than placebo. Nevertheless, the current evidence is not strong enough to conclude that ACB is superior to FNB; further well-designed studies are required to address this issue.

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