Original Article

Comparison of Post-Operative Analgesia between Adductor Canal Block and Femoral Nerve Block after Arthroscopic Anterior Cruciate Ligament Reconstruction: A Randomized Controlled Trial

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Objective: To determine whether adductor canal block (ACB) is non-inferior to femoral nerve block (FNB) in pain relief and whether ACB is superior to FNB in quadriceps strength after arthroscopic anterior cruciate ligament reconstruction (ACLR) with hamstring graft.

Materials and Methods: A blinded, randomized, non-inferiority trial was performed in patients undergoing ACLR with hamstring graft. They were randomly assigned ACB or FNB. The primary outcome was a non-inferiority comparison of visual analogue scale (VAS) pain scores (0 to 100 mm) within 24 hours post-operatively. The secondary outcomes were opioid consumption, opioid-free duration, quadriceps strength in percentage of body weight, ability to discharge, and opioid side effects. Non-inferiority margin of ACB to FNB was considered to be 50% of clinically significant difference (VAS 5 mm). Other outcomes were tested for superiority. The present trial was registered with the ClinicalTrials.gov, number NCT 02411890.

Results: Fifty-six patients were included in the present analysis. The ACB group reported higher VAS pain scores compared to the FNB group without significance at rest 5.67 (95% CI –3.46 to 14.79; p=0.224) and at activity 7.64 (95% CI –2.56 to 17.85; p=0.142). The ACB group had significantly better quadriceps strength at 8-hours post-operative compared to the FNB group with a mean difference of 5.84 (95% CI 2.13 to 9.54; p=0.002). No significant differences in morphine consumption, free opioid time, ability to discharge, and opioid side effects between the groups were found.

Conclusion: The present study could not indicate that ACB was non-inferior to FNB in post-operative pain reduction after arthroscopic ACLR with hamstring graft. ACB showed superior quadriceps strength in the early post-operative period.

Keywords: Adductor canal block, Femoral nerve block, Anterior cruciate ligament reconstruction, Post-operative analgesia

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Outpatient arthroscopic anterior cruciate ligament reconstruction (ACLR) has been demonstrated as a safe, effective, and cost-saving procedure[1,2]. However, patients often report moderate to severe post-operative pain requiring narcotic analgesia for pain control, especially within 24 to 48 hours after surgery[1,3]. Acute pain not controlled with adequate analgesia is the most common anesthetic related complications of ACLR leading to delayed physical therapy and hospital readmission[4]. Therefore, techniques that provide effective pain control and minimize opioid use should be implemented as a part of multimodal analgesia after arthroscopic ACLR.

The effectiveness of pain control by femoral nerve block (FNB) has been reported in several previous studies[5-8]. However, some studies have reported that motor block of quadriceps muscle was associated with falls after FNB[9,10]. An alternative technique that preserves quadriceps motor function and provides effective pain relief should be sought. Adductor canal block (ACB), the injection of local anesthetic at the level of adductor canal comprising of the saphenous

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nerve, only the sensory nerve, has been demonstrated as non-inferior efficacy in post-operative analgesia and better quadriceps function compared with FNB after total knee arthroplasty[11-13]. However, the efficacy in post-operative pain relief and quadriceps function of ACB after arthroscopic ACLR with hamstring graft is unknown. Therefore, the present study aimed to determine the non-inferiority of efficacy in pain relief of ACB compared with FNB and the superiority of ACB compared with FNB in quadriceps strength in 24 hours post-operative arthroscopic ACLR with hamstring graft.

Materials and Methods

The present study was approved by the Human Ethics Committee of Thammasat University and registered with www.ClinicalTrials.gov (NCT 02411890). All patients who met the inclusion criteria and exclusion criteria were invited to participate in the study and gave written informed consents. The inclusion criteria were elective arthroscopic ACLR with hamstring graft, age between 15 and 80 years, and the American Society of Anesthesiologists physical status classification of I to III. The exclusion criteria were patient refusal to participate in the study, a body mass index of 35 kg/m² or greater, allergy to any medication used in the study, chronic opioid use or abuse, previous lower extremity neurological dysfunction, and inability to cooperate and assess pain scores.

Patients were randomly assigned to either receive ACB or FNB in a1:1 ratio of allocation and using parallel trial design. A computer-generated randomization list with varied block sizes of four and six was used. The sequence of randomization was concealed by sealed envelopes opened after enrollment. All patients, surgeons, outcome assessors, and data analyzer were blinded except for the anesthesiologists who performed the blocks (Seangleulur A or Manuwong S).

The day before the surgery, a blinded research assistant asked patients for informed consent, obtained patient demographic data, and assessed preoperative pain scores along with quadriceps strength.

Preoperative midazolam (2 or 3 mg) was given intravenously in the block area. The ACB and FNB blocks were performed before spinal anesthesia by anesthesiologists experienced in ultrasound-guided nerve block (Vivid-e9, GE Healthcare, Horten, Norway). During block, the patients were blinded by a sham block. The patients in the ACB group received a sham block of the femoral nerve in the inguinal area, and then ACB was performed in the mid-femoral area. The patients in the FNB group received a sham block of adductor canal, followed by FNB.

After standard monitoring, an ultrasound-guided ACB (15 mL of 0.5% levobupivacaine with 5 µg/mL adrenaline) via a 22-gauge, 10-centimeters uniplex needle (PAJUNK, Geisingen, Germany) was performed using a high-frequency linear transducer. The injection site was identified from mid-femoral level, adjacent to femoral artery, under sartorius muscle. Ultrasound-guided FNB (30 ml of 0.25% levobupivacaine with 5 µg/ml adrenaline) was injected at inguinal area via a 22-guage 5-centimeters uniplex needle (PAJUNK, Geisingen, Germany).

While performing the blocks, all patients closed their' eyes. The sham block involved the injection of local anesthetic in the subcutaneous tissue (2 mL of 2% lidocaine) via a 22-gauge needle at the block sites with an ultrasound survey. Both block needle sites were covered with opaque plasters.

The success of each block was evaluated by blinded investigators 15 minutes after the block. Loss of sensation at either the infrapatellar region or the medial calf was tested every five minutes. Failed block was documented if there was no loss of sensation greater than 30 minutes after the block was performed. Spinal anesthesia was then performed with 2.5 to 3.5 mL of 0.5% isobaric or heavy bupivacaine.

In the operative room, the patients received cefazolin 1 g and ketorolac 30 mg intravenously. A tourniquet pressure of 350 mmHg was applied on the operated thigh for a time limit not exceeding 120 minutes. A drain was inserted, and a knee brace was applied in all patients post-operatively.

Post-operatively, the patients received disposable patient-controlled analgesia (PCA) for parenteral morphine as needed to control pain to a visual analog scale (VAS) of less than 40 with a PCA setting of a dose of 2.5 mg for the patients of 60 years or younger or 2 mg for the patients older than 60 years, no basal rate, and a lock out time of five minutes. Post-operative analgesic regimen was etoricoxib 90 mg one tablet orally once daily, paracetamol 500 mg one tablet orally every six hours, reparil two tablets orally three times per day, and myonal one tablet orally three time per day. The drain was removed by surgeons the next day. The patients were allowed to walk with full weight bearing with crutches after drain removal.

Outcomes

The primary outcome was VAS in 24 hours post-operatively during activity. At recruitment into the study, the patients were instructed on the use of the 0

to 100 mm VAS with 0 and 100 mm referring to 'no pain' and 'worst pain imaginable', respectively. VAS was also assessed at four hours post-operative and then every four hours, at rest and at activity until 24 hours post-operatively.

Total opioid consumption in the first 24 hours post-operative and the first time that the patient pressed the PCA (VAS of 40 or more) was also recorded. Opioid side effects including nausea vomiting, pruritus, respiratory depression, and urinary retention were recorded. Nausea, vomiting, and pruritus were recorded as a 0 to 2 scale with 0=none, 1=mild symptom without treatment, and 2=severe symptom with need of treatment. Respiratory depression was recorded as 'yes' defined as a respiratory rate 8 or less per minute, and 'no'. Urinary retention was measured as 'yes' defined as needing urinary catheterization, and 'no'.

Quadriceps strength was assessed as maximum voluntary isometric contraction (MVIC) preoperatively, at 8, and at 24 hours post-operatively with a handheld dynamometer (HHD) (Lafayette Instrument, Lafayette, IN), which had already been calibrated. HHD is a reliable and valid instrument for measuring quadriceps strength[14]. Strength was evaluated by a blinded research assistant using a Velcro strap to fix the dynamometer to reduce inter-rater reliability. The patients sat with 60 degrees of knee flexion with the HHD attached at 5 cm above the transmalleolar axis. The patients were asked to extend their knee as forcefully as possible in three seconds with instruction given by of the assessor saying, "push-push-push-pause". Strength was measured three times, and the maximum value was recorded. Then, the maximal torque was calculated by multiplying the maximal force in newtons with the distance between femoral condyle and HHD in meters. The torque after calculation was converted from newtons to kilograms and reported in the percentage of the body weight of the patient.

The ability for readiness for hospital discharge within 24 hours post-operative was recorded. The criteria of readiness for hospital discharge was defined as the patient being alert and responsive to questioning, showing acceptable pain and nausea control, being able to urinate, and being able to walk with crutches. All outcomes were assessed by blinded outcome assessors, who were not involved in other parts of the study.

Statistical analysis

Sample size calculation was done with a non-inferiority margin of 50% of the minimum clinically significant difference. The minimum clinically significant difference of VAS was 1 of 10 pain score or 33% decrease in pain score[15]. Therefore, the authors decided to use 50% of 1, or 5 mm in 100 mm, as the non-inferiority margin in the present study. From a previous study[5], the mean VAS pain scores during activity at 24 hours post-operative for FNB was 32 mm (SD 6). The authors assumed that the SD would be the same for ACB. Thus, calculated that 25 subjects were needed per group to test the given non-inferiority hypothesis at 90% power and 0.05 for type I error. Assuming a 15% dropout rate, the final calculated sample size was 60 patients.

Continuous data were presented as mean (SD) or median (IQR) as appropriated, and categorical data were presented as frequency in percentage. Comparison between continuous data was performed by t-test or Mann-Whitney U test depending on data distribution. A multilevel linear model was used to find the association between VAS, different measured time points, and blocks. The difference in morphine consumption was demonstrated with linear regression analysis. Time to event analysis was used to compare the duration that VAS was less than 4, and presented as median time and hazard ratio. Categorical variables were compared by chi-square or Fischer-exact test. A p-value of 0.05 or less was considered statistically significant. Statistical analysis was performed using Stata version14.0 (StataCorp, 2015. College Station, TX).

Results

Sixty patients were enrolled between March 2014 and February 2015. The recruitment flow through the study is shown in Figure 1. All blocks were successful. After randomization, two patients in ACB group were excluded because post-erolateral corner reconstruction was also performed. One patient in FNB group was excluded because ACL was not reconstructed, and another patient in this group had patellar bone (PTB) graft. Therefore, twenty-eight patients per groups were included in the present analysis. Patients' demographic and characteristics were similar between groups (Table 1).

There was no difference in pairwise comparison of VAS both at rest and at activity in first 24 post-operative hours between the groups except for VAS at 24 hours at rest, which was reported as significantly higher pain score by the ACB group (Table 2). To test our non-inferiority hypothesis for VAS, we added different measured time points into the multilevel

Table 1. Patient demographic and characteristics

	ACB group (n = 28) n (%)	FNB group (n = 28) n (%)	p-value
Age (year), Median (IQR)	32.5 (23.5, 39.5)	31 (26, 35.5)	0.294
Sex			0.422
Male	26 (92.86)	23 (82.14)	
Female	2 (7.14)	5 (17.86)	
BMI (kg/m^2), Mean±SD	25.89±3.63	24.46 (4.31)	0.186
ASA physical status			1.000
I	24 (85.71)	25 (89.29)	
II	4 (14.29)	3 (10.71)	
Surgeon			0.786
I	17 (60.71)	16 (57.14)	
II	11 (39.29)	12 (42.86)	
Side of operation			0.593
Left	15 (53.57)	13 (46.43)	
Right	13 (46.43)	15 (53.57)	
Operative duration (minutes), Median (IQR)	101 (77.5, 136.5)	112.5 (85, 136)	0.287
Preoperative VAS at activity, Median (IQR)	0 (0, 19)	0 (0, 3)	0.628

ACB=adductor canal block; ASA=American Society of Anesthesiologists; BMI=body mass index; FNB=femoral nerve block; IQR=interquartile range; SD=standard deviation; VAS=visual analog scale

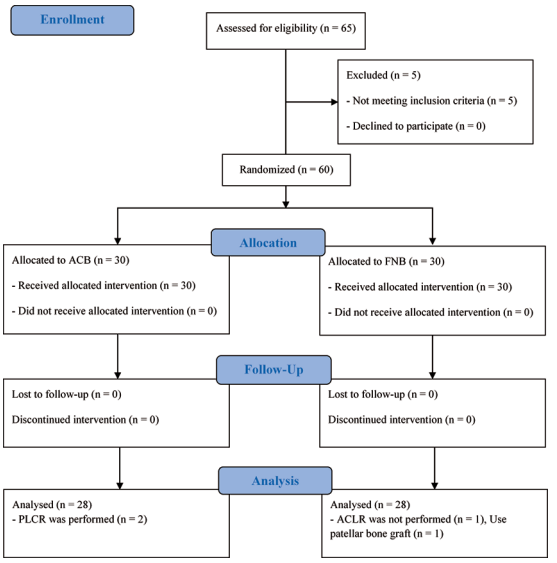

Figure 1. Consolidated standards of reporting trials statement flow diagram.

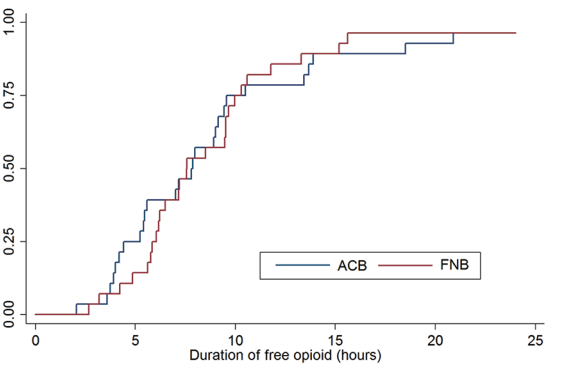

Figure 2. Kaplan-Meier plot shows duration of free opioid comparing between adductor canal block (ACB) and femoral nerve block (FNB).

linear model and found that the ACB group reported higher pain scores compared with the FNB group with mean differences of 5.67 (95% CI –3.46 to 14.79) at rest and 7.64 (95% CI –2.56 to 17.85) at activity. The delta margin of non-inferiority (the difference of VAS of 5 or less) laid inside the 95% CI range. Therefore, this could not conclude the non-inferiority of ACB to FNB in pain score reduction.

The amount of intravenous morphine consumption during the 24 hours post-operative was 17.5 mg (10, 22.5) in the ACB group and 11.25 mg (6.25, 27.5) in the FNB group. There was no difference in cumulative morphine with a mean difference of 5 mg (95% CI –4.89 to 14.89; p=0.315). The median time of free opioid consumption in the ACB group and the FNB group was 7.8 hours (5.42, 9.15) and 7.57 hours (6.17, 9.52), respectively (Figure 2). The hazard ratio of free opioid duration of the ACB group was 1.02 (95% CI 0.59 to 1.73; p=0.957) higher compared to the FNB group.

Table 2. VAS pain scores at rest, at activity and morphine consumption during 24 post-operative hours

	ACB group (n = 28) Median (IQR)	FNB group (n = 28) Median (IQR)	p-value
VAS, 4 hours			
At rest	0 (0, 11)	0 (0,8)	0.797
At activity	0 (0, 20.5)	9 (0, 10.5)	0.241
VAS, 8 hours			
At rest	14 (3, 28.5)	8.5 (0, 33)	0.561
At activity	30 (8.5, 42)	13 (1, 40)	0.397
VAS, 12 hours			
At rest	25.5 (11.5, 35.5)	18 (2.5, 41.5)	0.271
At activity	35.5 (24, 51.5)	28 (10, 48)	0.317
VAS, 16 hours			
At rest	24 (7, 43.5)	14 (3, 38.5)	0.249
At activity	35 (19, 60)	21 (14.5, 48.5)	0.187
VAS, 20 hours			
At rest	30.5 (15.5, 62)	18 (32.5)	0.078
At activity	39.5 (26, 66.5)	29.5 (14,35)	0.164
VAS, 24 hours			
At rest	26.5 (18, 37.5)	13.5 (5, 30)	0.030*
At activity	49 (26, 65.5)	29 (19, 50.5)	0.084

ACB=adductor canal block; FNB=femoral nerve block; IQR=interquartile range; VAS=visual analog scale

* Statistical significance, p<0.05

Table 3. Quadriceps strength of operated knee at preoperative, 8, and 24 post-operative hours

	ACB group (n = 28)	FNB group (n = 28)	p-value
QS preoperative (% BW), Mean±SD	38.69±7.10	38.53±7.78	0.936
QS at 8 hours (% BW), Median (IQR)	14.05 (9.30, 23.36)	0 (0, 5.74)	0.002*
QS at 24 hours (% BW), Median (IQR)	16.25 (5.00, 25.68)	9.56 (5.91, 25.14)	0.369

ACB=adductor canal block; BW=body weight; FNB=femoral nerve block; IQR=interquartile range; QS=quadriceps strength; SD=standard deviation

* Statistical significance, p<0.05

There was no difference in pre-operative quadriceps strength between the groups (Table 3). Quadriceps strength of the ACB group at 8-hours post-operatively was 14.05% (9.30, 23.36), and this was significantly higher compared with 0% (0, 5.74) of those in the FNB group with a difference of 5.84 (95% CI 2.13 to 9.54; p=0.002) (Table 3). Two patients in the ACB group and 15 patients in the FNB group could not perform the test due to quadriceps weakness while four patients in the ACB group and three patients in the FNB could not extend their legs because of severe pain. At 24 hours post-operative, there was no significant difference in quadriceps strength between the ACB group and the FNB group with a mean difference of 1.86% (95% CI –2.20 to 5.92; p=0.369) (Table 3). Two patients in the FNB group still reported quadriceps weakness. Six patients (three in the ACB group and three in the FNB group) reported severe pain and could not perform the test.

There was no difference between groups in either the number of patients who could be discharged at 24 hours post-operative or the reported side effects of opioids (Table 4).

Discussion

The present study demonstrated no difference in pain control during the first 24 post-operative hours after arthroscopic ACLR with hamstring graft between ACB and FNB while ACB could preserve quadriceps function better than FNB.

Two previous studies have compared ACB and FNB in pain control after ACLR, and their results

Table 4. The ability to discharge from the hospital and opioid side effects

	ACB group (n = 28) n (%)	FNB group (n = 28) n (%)	p-value
Fulfill discharge criteria at 24 hours	20 (71.43)	21 (75.0)	0.763
Actual discharge at 24 hours	4 (14.29)	3/25 (10.71)	0.686
Nausea and vomiting (0/1/2)			0.709
No symptom	21 (75)	18 (64.29)	
Mild symptom	5 (17.86)	4 (14.29)	
Severe symptom	2 (7.14)	6 (21.42)	
Pruritus (0/1/2)			0.669
No symptom	26 (92.86)	24 (85.72)	
Mild symptom	2 (7.14)	3 (10.71)	
Severe symptom	0 (0.0)	1 (3.57)	
Urinary retention	0 (0.0)	0 (0.0)	1.000
Respiratory depression	0 (0.0)	0 (0.0)	1.000

ACB=adductor canal block; FNB=femoral nerve block

were discordant[16,17]. El Ahl[16] found that ACB provided less analgesia compared with that of FNB, but Chisholm et al[17] reported that ACB provided similar and adequate post-operative analgesia when compared with FNB. Although the results of the current study were similar to Chisholm et al, the research methodologies of these studies differed from the present study. First, the present study focused on studying ACLR with hamstring graft whereas patients undergoing PTB graft were the target population of those studies. While pain from PTB graft can be effectively managed by FNB or ACB, the hamstring muscle is supplied by the sciatic nerve, and pain from harvesting graft was not covered by these blocks. A significant increase in acute post-operative pain was reported when performing ACLR with PTB compared with hamstring graft[18]. However, the authors decided to study hamstring graft because the majority of patients had this graft type performed, and a previous study reported that pain from hamstring graft was adequately managed with multimodal analgesia in an outpatient setting[1]. Because El Ahl[16] also performed block at the end of surgery, the success of block could not be tested. The success of block in the present study was tested before surgery.

Although no difference in pain control between these interventions was reported in the superiority test, the 95% CI of the mean pain score difference was quite wide, and the margin set laid over the range of 95% CI for non-inferiority test. Therefore, the results from the present study were indeterminate as to whether ACB is non-inferior to FNB in pain management. Another study published during the authors preparing manuscript reported that ACB was non-inferior compared with FNB in pain control after ACLR[19]. However, the setting of the non-inferior margin of the present study differed from that study. The primary outcome of the present study was pain score, and the non-inferiority margin was set at 50% of minimally clinically important difference in pain score, which was smaller than that of Abdallah et al[19], who set the margin at a 25% difference of each outcome. The present study compared the mean difference of pain scores at different time points between groups by multilevel analysis adding time as a factor, which makes clinical interpretation easier compared with using the area under curve of pain scores.

Because the authors were also interested in the difference of analgesic duration of each block, we compared the duration of free opioid consumption, which means a pain score of lower than 40. No difference in median time of free opioid between groups was found. However, the median time of free opioid in the present study was shorter than the analgesic effect of either ACB or FNB in healthy volunteers, which might have been caused by the pain resulting from harvesting hamstring graft needed strong opioids for controlling pain[20].

The results demonstrated more preservation of quadriceps strength after ACB compared with FNB eight hours post-operative, but the difference was not found at 24 hours post-operative when the effect of both blocks had worn off. However, there was a reduction in quadriceps strength in the ACB group post-operative compared with preoperative period. This may have been caused by the weakness of the

quadriceps from the spreading of local anesthetic to the nerve that supplies the vastus medialis or severe post-operative pain limiting the strength of the patient[21]. Abdallah et al also reported ACB preserved quadriceps strength compared to FNB. However, they measured muscle strength preoperatively while the present study measured after surgery, which provides more clinical information[19].

The present study has several limitations. First, only patients undergoing ACLR with hamstring graft and not those with PTB graft participated in the present study, thus, this could not apply to patients with PTB graft because the severity of post-operative pain is not similar. Second, the present study was planned in an ambulatory setting. However, the amount of opioid consumption is an outcome of interest, and strong opioid in oral form is not available at the study center. Therefore, the authors had to study in an inpatient setting, and the ability to discharge at 24 hours post-operative was added as an outcome of interest. The authors also could not conclude the non-inferiority of ACB compared with FNB because lack of power. In the present study, sample size was estimated from the mean pain score and the standard deviation from a previous study that differed from the results of the present study, and 116 patients were needed for the present study to prove the hypothesis. Finally, there is no definite guideline about the appropriate non-inferiority margin, and it depends on the decision of the authors. The heterogeneity of non-inferiority margin between studies makes comparison between studies problematic.

Conclusion

The present study could not indicate that ACB was non-inferior to FNB in post-operative pain reduction after arthroscopic ACLR with hamstring graft. However, ACB provided better quadriceps function compared with FNB in the early post-operative period.

What is already known on this topic?

FNB is an effective technique in post-operative pain control after ACLR and is usually added as a part of multimodal analgesia; however, it reduces patients' quadriceps strength, which may delay hospital discharge and lead to fall after surgery. The introduction of ACB, a sensory nerve block, is non-inferior to FNB in pain control and preserve quadriceps strength better after total knee arthroplasty. The efficacy of ACB compared with FNB after ACLR is still inconclusive.

What this study adds?

The efficacy in pain control after ACLR with hamstring graft of ACB compared with FNB is still uncertain, but ACB provides better quadriceps function.

Conflicts of interest

The authors declare no conflict of interest.

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