Postoperative Pain Control After ACL Reconstruction With Semitendinosus Tendon Graft

A Randomized Controlled Trial Comparing Adductor Canal Block to Local Infiltration Analgesia

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Background: Both adductor canal block (ACB) and local infiltration (LI) are effective for postoperative pain management after arthroscopic-assisted anterior cruciate ligament (ACL) reconstruction (ACLR). While LI is a more straightforward procedure, its effectiveness remains debated.

Purpose: To evaluate morphine consumption within 48 hours after ACLR with a semitendinosus tendon graft, comparing ACB and LI; secondary objectives: to evaluate pain levels, patient satisfaction, quadriceps strength, range of knee motion, and complications.

Study Design: Randomized controlled trial; Level of evidence, 1.

Methods: Patients undergoing primary ACLR with a semitendinosus tendon graft were randomized to receive either ACB (0.25% bupivacaine; 20 mL) or LI at the surgical wound, graft harvest area, and intra-articular injection. The LI group received morphine (3 mg), ketorolac (30 mg), and tranexamic acid (1 g). Morphine consumption within 48 hours was monitored using an intravenous patient-controlled analgesia device.

Results: A total of 48 patients were analyzed (n = 24 in each group); baseline characteristics were similar between groups. The LI group consumed significantly less morphine than the ACB group at 6 hours (median [interquartile range, IQR], 3 mg [0-4.8 mg] for the LI group vs 5.5 mg [2-9] for the ACB group; $P = .003$). However, no significant differences were observed in morphine consumption at other time points. Additionally, no significant difference was found in cumulative morphine consumption at 48 hours between the groups (median [IQR], 21.5 mg [11-34.5 mg] for the ACB group vs 16.5 mg [8.5-21.8 mg] for the LI group; $P = .137$). Postoperative pain scores, quadriceps strength, and patient satisfaction were similar between the 2 groups.

Conclusion: Morphine consumption at 48 hours postoperatively was comparable between the LI and ACB groups, and no significant group differences were found in postoperative pain, quadriceps strength, or patient satisfaction.

Registration: TCTR20190320003 (Thai Clinical Trial Registry).

Keywords: adductor canal block; anterior cruciate ligament reconstruction; local analgesia; morphine consumption; postoperative pain control

Effective postoperative pain management is crucial, especially for patients undergoing anterior cruciate ligament (ACL) reconstruction (ACLR).[2] Proper pain control significantly influences surgical outcomes, patient satisfaction, hospital stay duration, and the onset of early rehabilitation.[4,6] Various methods have been identified to mitigate postoperative pain—including peripheral nerve blocks, intra-articular and periarticular injections, intravenous and intramuscular injections, percutaneous peripheral nerve stimulation, and oral medication.[6,14,19,21,15,13,17,8] In

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the context of ACLR, adductor canal block (ACB) and local infiltration (LI) have been recognized as effective strategies, each offering distinct advantages over the femoral nerve block.[7] However, the relative effectiveness of ACB versus LI specifically for pain management after arthroscopic-assisted ACLR remains unclear.

This study aimed to evaluate and compare the effectiveness of ACB and LI in controlling postoperative pain in patients who have undergone arthroscopic-assisted ACLR. The primary focus was to measure the consumption of morphine in the initial 48 hours after surgery. We also aimed to assess secondary outcomes related to postoperative recovery, such as pain levels within the first 48 hours, knee range of motion, quadriceps muscle strength, patient satisfaction, and any associated complications.

METHODS

After receiving approval from our ethics review board, we conducted a 2-arm, parallel-group randomized controlled trial at a single institution from July 2019 to April 2020. Participants aged ≥18 years who were undergoing primary arthroscopic-assisted ACLR with a semitendinosus tendon graft were eligible. The exclusion criteria encompassed avulsion ACL fracture, revision ACL tear, concomitant ligament injuries necessitating surgery, previous surgery on the ipsilateral knee, documented drug abuse, renal insufficiency (glomerular filtration rate <30 mL/min), contraindications to spinal anesthesia, allergies to ketorolac, morphine, tranexamic acid, parecoxib, and paracetamol, and those with a risk for cardiovascular thrombotic events, peptic ulcers, or gastrointestinal bleeding. Participants were randomly allocated in a 1 to 1 ratio using a computer-generated number list with blocks of 4. Although the treatment allocation was not blinded, the treatment group was concealed during data collection and analysis.

The study sample size was based on a previous study showing an 8.5-mg mean morphine consumption difference between the ACB and LI groups,[16] deeming a 10-mg mean difference as clinically significant. With 80% power and α = .05, anticipating a 5% dropout rate, we required 24 patients per group. We assessed a total of 77 patients for eligibility. Of these patients, 29 were excluded because of multiligamentous injury, avulsion fracture of the tibial spine, or revision ACLR. In total, 48 patients (n = 24 in each group) were included and evaluated, with no dropouts observed during the study (Figure 1).

Before surgery, all participants were instructed on the use of a patient-controlled analgesia (PCA) device for self-administered pain management. The PCA device contained morphine, which was diluted in normal saline to a concentration of 1 mg/mL. Patients were able to administer a 1-mg dose of morphine with each activation of the PCA, with a mandatory 5-minute interval between doses. The maximum allowable morphine dosage was set at 10 mg/h. This protocol was designed to ensure uniform morphine consumption across both study groups, facilitating a fair comparison of pain management effectiveness.

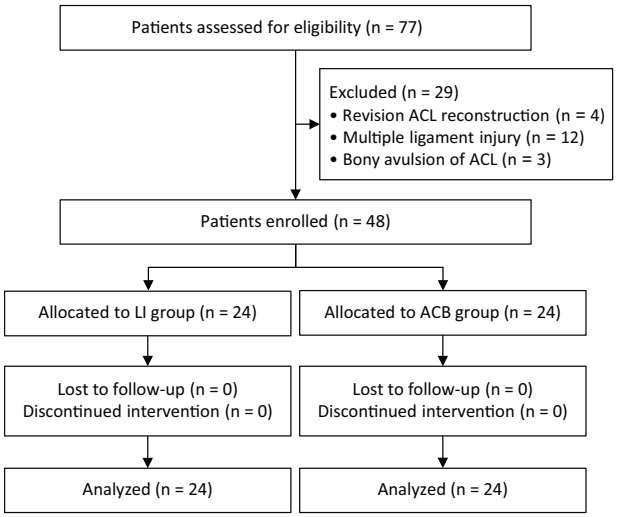

Figure 1. CONSORT flow diagram of the patient inclusion process. ACB, adductor canal block; ACL, anterior cruciate ligament; CONSORT, Consolidated Standards of Reporting Trials; LI, local infiltration.

Participants received either postoperative ACB under ultrasound guidance, administered by an experienced regional anesthesiologist (A.W.) using 0.25% bupivacaine (20 mL), or LI at the surgical wound, graft harvesting site, and intra-articular injection. The LI consisted of morphine (3 mg), ketorolac (30 mg), tranexamic acid (1 g), and normal saline up to 50 mL: graft harvest site (15 mL), surgical wound (5 mL), and intra-articular injection (30 mL). All participants underwent spinal anesthesia with 0.5% bupivacaine, achieving a sensory block level between T8 and T10. The surgeries were conducted by 3 experienced surgeons (A.B., S.S., or P.A.) using a consistent surgical technique. To maintain the integrity of the study's blinding, the treatment regimen for each patient (ACB vs LI) was predetermined and concealed within a sealed, opaque envelope. This envelope was opened by a nurse only after the completion of the surgery to verify the treatment

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Ethical approval for this study was obtained from Khon Kaen University (reference No. HE621215).

TABLE 1
Comparison of Patient Characteristics by Study Group[a]

Characteristic	LI Group (n = 24)	ACB Group (n = 24)
Age, y	29.1 ± 10.5	32.5 ± 11
Sex		
Male	23	23
Female	1	1
Weight, kg	73 ± 12.8	70.3 ± 9.2
BMI, kg/m^2	24 ± 2.8	24.3 ± 3.6
Meniscectomy	8	7
Meniscorrhaphy	8	12
Combined meniscal surgery	6	3
No meniscal surgery	2	2
Operative time, min	90.3 ± 18.3	101 ± 31.9

[a]Data are presented as mean ± standard deviation or No. of patients. ACB, adductor canal block; BMI, body mass index; LI, local infiltration.

TABLE 2
Comparison of Morphine Consumption by Study Group[a]

Time After Surgery, Hours	LI Group	ACB Group	*P*
PACU, 2	0 (0-1)	0.5 (0-1)	.326
6	3 (0-4.8)	5.5 (2-9)	**.003**
12	2.5 (0-5.8)	3 (1-6)	.376
24	4 (2-7.5)	4 (2-8.5)	.732
48	4 (1.3-5.6)	5 (0.3-9.8)	.480

[a]Data are presented as median (IQR). The bold *P* value indicates a statistically significant difference between groups ($P < .05$). ACB, adductor canal block; IQR, interquartile range; LI, local infiltration; PACU, postanesthesia care unit.

assigned and align postoperative care with the initial randomization. This method was essential to minimize bias during the surgical procedure. For the first 48 hours postoperatively, patients received morphine via the PCA device.

Outcomes Assessment

Morphine consumption (in mg) was recorded while the patients were in the postanesthesia care unit (2 hours), then at 6, 12, 24, and 48 hours postoperatively, with pain intensity both at rest and during motion monitored using a numeric rating scale (NRS; 0 [no pain] to 10 worst pain. Patient satisfaction (NRS; 0 [very dissatisfied] to 10 [very satisfied]), knee range of motion, quadriceps muscle strength, and the incidence of side effects were assessed at the 48-hour postoperative mark by an evaluator (K.J.) blinded to the treatment assignment to ensure unbiased data collection. Knee range of motion was assessed as the ability to perform straight-leg raises. Quadriceps muscle strength was evaluated using the Medical Research Council scale (range, 0-5), where 0 = no contraction or movement, 1 = flicker or trace contraction, 2 = active movement, with gravity eliminated, 3 = active movement against gravity, 4 = active movement against gravity and resistance, and 5 = normal power.

Statistical Analysis

Statistical analyses were performed using SPSS software Version 26 for Windows (IBM Corp). Characteristics data were compared between the ACB and LI groups using the chi-square or the Fisher exact test for categorical data and the Student *t* test for continuous data. Data normality was assessed using the Kolmogorov-Smirnov test. The *t* test was used to analyze normally distributed data, while the Mann-Whitney *U* test was used to compare nonnormally distributed data. Cumulative morphine consumption at 0, 6, 12, 24, and 48 hours postoperatively was analyzed, and confounding factors were controlled using generalized estimating equations. The significance threshold was set at $P < .05$.

RESULTS

The baseline characteristics were similar between the 2 treatment groups, with a mean age of 29.1 years in the LI group and 32.5 years in the ACB group. Meniscal surgery was performed in 22 patients (91.6%) in both groups. The patient characteristics are shown in Table 1.

Morphine consumption is presented in Table 2. The LI group exhibited a significant reduction in postoperative morphine consumption at 6 hours (median [interquartile range, IQR], 3 mg [0-4.8 mg] for the LI group vs 5.5 mg [2-9] for the ACB group; $P = .003$). However, there was no significant difference at other time points, nor was there a significant difference in cumulative morphine consumption at 48 hours between the groups (median [IQR], 21.5 mg [11-34.5] for the ACB group vs 16.5 mg [8.5-21.8] for the LI group; $P = .137$) (Figure 2). No significant differences were observed in postoperative pain scores, quadriceps strength, or patient satisfaction between the 2 groups (Tables 3 and 4).

DISCUSSION

ACB and LI have been widely used for many years to mitigate postoperative pain, both with well-established safety profiles. In our study, total postoperative morphine consumption at 48 hours was similar between the ACB and LI groups ($P = .137$). This result aligns with a recent randomized study that compared ACB and LI in 52 participants and found no significant difference between the groups.[16]

However, we found a significant decrease in postoperative morphine consumption at 6 hours in the LI group compared with the ACB group. One study revealed that an intra-articular injection containing ropivacaine, epinephrine, morphine, and methylprednisolone can notably decrease postoperative morphine consumption compared

TABLE 3
Comparison of Postoperative Pain by Study Group[a]

	Pain at Rest, NRS			Pain During Motion, NRS		
Time After Surgery, Hours	LI Group	ACB Group	*P*	LI Group	ACB Group	*P*
PACU, 2 h)	0 (0-0)	0 (0-0)	.589	0 (0-0)	0 (0-0)	.246
6	0.5 (0-3.8)	3 (0.5-4.8)	.065	3 (0-5)	5 (3-6)	.121
12	2 (0-3)	3 (2-3)	.241	5 (2-5)	4.5 (3-5.8)	.600
24	2 (0.3-4)	3 (0-4.8)	.442	4.5 (2.3-5.8)	5 (3-5)	.826
48	0 (0-2)	2 (0-2.8)	.312	3 (2-5.8)	3 (3-4.8)	.850

[a]Data are presented as median IQR. ACB, adductor canal block; IQR, interquartile range; LI, local infiltration; NRS, numeric rating scale; PACU, postanesthesia care unit.

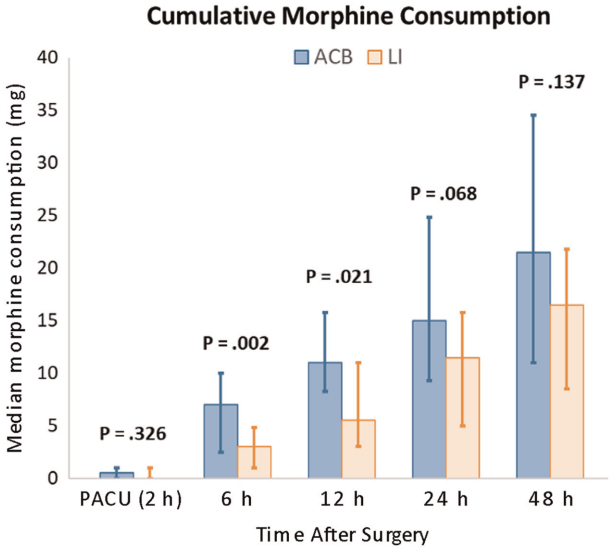

Figure 2. Comparison of cumulative postoperative morphine consumption between the ACB and LI groups. No significant group difference was observed in the median morphine consumption at 48 hours after surgery (21.5 [ACB group] vs 16.5 mg [LI group]; *P* = .137). Error bars represent the IQR. ACB, adductor canal block; IQR, interquartile range; LI, local infiltration; PACU, postanesthesia care unit.

with a femoral nerve block.[11] A systematic review and meta-analysis also demonstrated that LI is superior to peripheral nerve block, and no significant difference was found between ACB and placebo in terms of reducing postoperative morphine consumption.[15,19,21] Rebound pain, which causes hyperalgesia after the peripheral nerve block wears off, may be a reason for increased morphine consumption, occurring frequently within the first 24 hours and exceeding 40% at 48 hours postoperatively.[18] This phenomenon is predominantly associated with younger patients and bone surgeries, similar to the participants in this study.[1] Several multimodal preventative strategies, like preemptive analgesia, continuous peripheral nerve block, and combined nerve block, have proven beneficial.[6,2,3,5,10,20]

Conversely, previous systematic reviews and meta-analyses have produced varied outcomes concerning the efficacy of distinct drugs and dosages in alleviating postoperative pain.[9] Bupivacaine, given its chondrotoxic effects, is contraindicated for intra-articular injections.[12] Optimal drug selection and dosage for local analgesia remain a challenge.

TABLE 4
Comparison of Secondary Outcomes by Study Group[a]

Outcome	LI Group	ACB Group	*P*
Quadriceps strength, MRC scale	4.3 ± 0.9	3.9 ± 1.1	.254
Can perform straight-leg raises	22	20	.762
Patient satisfaction, NRS	8.4 ± 1.2	8.6 ± 1	.479
Adverse effects			
Nausea and vomiting	1	2	.356
Superficial wound infection	1	0	.312

[a]Data are presented as mean ± standard deviation or No. of patients. ACB, adductor canal block; LI, local infiltration; MRC, Medical Research Council; NRS, numeric rating scale.

Limitations

This study has limitations. All participants underwent ACLR by 3 different surgeons, potentially introducing bias, even though the same surgical technique was applied. While double-blinding was not feasible, the surgeons did conceal the interventions to reduce bias. Incorporating a control group, either receiving no treatment or both interventions, would have facilitated a more thorough efficacy comparison.

CONCLUSION

In this study, the LI group demonstrated a significant reduction in postoperative morphine consumption compared with the ACB group at 6 hours after surgery. However, no significant differences were observed in morphine consumption at other time points, and no significant difference was found between the groups in cumulative morphine consumption at 48 hours. Moreover, no substantial differences were found in pain scores,

quadriceps strength, or patient satisfaction. Future studies should explore the most effective drug components and dosages for LI or combined nerve block to enhance postoperative pain management.

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REFERENCES

1. Barry GS, Bailey JG, Sardinha J, Brousseau P, Uppal V. Factors associated with rebound pain after peripheral nerve block for ambulatory surgery. *Br J Anaesth*. 2021;126(4):862-871.
2. Buckthorpe M, Gokeler A, Herrington L, et al. Optimising the early-stage rehabilitation process post-ACL reconstruction. *Sports Med*. 2024;54(1):49-72.
3. Chelly JE, Delaunay L, Williams B, Borghi B. Outpatient lower extremity infusions. *Best Pract Res Clin Anaesthesiol*. 2002;16(2):311-320.
4. Chmielewski TL, Jones D, Day T, Tillman SM, Lentz TA, George SZ. The association of pain and fear of movement/reinjury with function during anterior cruciate ligament reconstruction rehabilitation. *J Orthop Sports Phys Ther*. 2008;38(12):746-753.
5. Ding DY, Manoli A, Galos DK, Jain S, Tejwani NC. Continuous popliteal sciatic nerve block versus single injection nerve block for ankle fracture surgery: a prospective randomized comparative trial. *J Orthop Trauma*. 2015;29(9):393-398.
6. Hampton H, Torre M, Satalich J, et al. Benefits of implementing an enhanced recovery after surgery protocol in ambulatory surgery. *Orthop J Sports Med*. 2022;10(11):23259671221133412.
7. Hussain N, Brull R, Vannabouathong C, et al. Network meta-analysis of the analgesic effectiveness of regional anaesthesia techniques for anterior cruciate ligament reconstruction. *Anaesthesia*. 2023;78(2):207-224.
8. Ilfeld BM, Plunkett A, Vijjeswarapu AM, et al. Percutaneous peripheral nerve stimulation (neuromodulation) for postoperative pain: a randomized, sham-controlled pilot study. *Anesthesiology*. 2021;135(1):95-110.
9. Kirkham KR, Grape S, Martin R, Albrecht E. Analgesic efficacy of local infiltration analgesia vs. femoral nerve block after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *Anaesthesia*. 2017;72(12):1542-1553.
10. Knight JB, Schott NJ, Kentor ML, Williams BA. Neurotoxicity of common peripheral nerve block adjuvants. *Curr Opin Anaesthesiol*. 2015;28(5):598-604.
11. Kurosaka K, Tsukada S, Nakayama H, et al. Periarticular injection versus femoral nerve block for pain relief after anterior cruciate ligament reconstruction: a randomized controlled trial. *Arthroscopy*. 2018;34(1):182-188.
12. Noyes FR, Fleckenstein CM, Barber-Westin SD. The development of postoperative knee chondrolysis after intra-articular pain pump infusion of an anesthetic medication: a series of twenty-one cases. *J Bone Joint Surg Am*. 2012;94(16):1448-1457.
13. Paul RW, Szukics PF, Brutico J, Tjoumakaris FP, Freedman KB. Postoperative multimodal pain management and opioid consumption in arthroscopy clinical trials: a systematic review. *Arthrosc Sports Med Rehabil*. 2022;4(2):e721-e746.
14. Secrist ES, Freedman KB, Ciccotti MG, Mazur DW, Hammoud S. Pain management after outpatient anterior cruciate ligament reconstruction: a systematic review of randomized controlled trials. *Am J Sports Med*. 2016;44(9):2435-2447.
15. Sehmbi H, Brull R, Shah UJ, et al. Evidence basis for regional anesthesia in ambulatory arthroscopic knee surgery and anterior cruciate ligament reconstruction: part II: adductor canal nerve block—a systematic review and meta-analysis. *Anesth Analg*. 2019;128(2):223-238.
16. Stebler K, Martin R, Kirkham KR, Lambert J, De Sede A, Albrecht E. Adductor canal block versus local infiltration analgesia for postoperative pain after anterior cruciate ligament reconstruction: a single centre randomised controlled triple-blinded trial. *Br J Anaesth*. 2019;123(2):e343-e349.
17. Stein AM, Bouché PA, Grimaud O, Vedrenne P, Hardy A. Pregabalin does not reduce postoperative pain after outpatient ACL surgery: a case-control study. *Orthop Traumatol Surg Res*. 2023;109(6):103596.
18. Sunderland S, Yarnold CH, Head SJ, et al. Regional versus general anesthesia and the incidence of unplanned health care resource utilization for postoperative pain after wrist fracture surgery: results from a retrospective quality improvement project. *Reg Anesth Pain Med*. 2016;41(1):22-27.
19. Vorobeichik L, Brull R, Joshi GP, Abdallah FW. Evidence basis for regional anesthesia in ambulatory anterior cruciate ligament reconstruction: part I—femoral nerve block. *Anesth Analg*. 2019;128(1):58-65.
20. Williams BA, Ibinson JW, Mangione MP, et al. Research priorities regarding multimodal peripheral nerve blocks for postoperative analgesia and anesthesia based on hospital quality data extracted from over 1,300 cases (2011-2014). *Pain Med*. 2015;16(1):7-12.
21. Yung EM, Brull R, Albrecht E, Joshi GP, Abdallah FW. Evidence basis for regional anesthesia in ambulatory anterior cruciate ligament reconstruction: part III: local instillation analgesia—a systematic review and meta-analysis. *Anesth Analg*. 2019;128(3):426-437.