

Clinical efficacy of adductor canal block in medial open wedge high tibial osteotomy

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ABSTRACT

Background: To evaluate the effect of adductor canal block (ACB) on short-term postoperative outcomes in patients who underwent medial open-wedge high tibial osteotomy (MOWHTO) compared to that of a placebo.

Methods: 35 patients who underwent unilateral MOWHTO between 2017 and 2019 were prospectively reviewed and randomly divided into two groups: 19 patients who received a single-shot ACB and 16 patients who received a saline injection (a placebo group). Primary outcomes were (1) pain measured using the visual analog scale and range of motion, (2) patient satisfaction, (3) postoperative need for additional opioids, (3) quadriceps strength (the time to straight leg raising [SLR]), (4) clinical outcomes, and (5) complications.

Results: The pain score was lower in the ACB group than in the placebo group in the first 12 h ($p = 0.04$). ACB did not exhibit significantly less quadriceps strength weakness postoperatively. There was no statistical difference in the time to SLR (23.5 ± 17.7 h in ACB vs. 27.6 ± 11.4 in placebo, $p = 0.520$). The opioid consumption rate within postoperative 12 h was significantly decreased after ACB (16.7% in ACB, 70% in placebo, $p = 0.017$). The proportion of patients with more than 5 opioid injections within 72 h postoperatively was lower in the ACB group (8.3% in ACB, 50% in placebo, $p = 0.043$). Both groups did not show any localized and systemic complications.

Conclusion: ACB following MOWHTO exhibited better outcomes than a placebo with respect to opioid consumption with no changes in the quadriceps strength and complications.

Level of Evidence: II, Prospectively comparative study

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1. Introduction

Appropriate pain management after high tibial osteotomy (HTO) allows for faster recovery, reduces the risk of postoperative complications, and improves patient satisfaction, resulting in decreased immobility-related complications and prolonged hospitalization [1]. Peripheral nerve blocks, such as the femoral nerve and adductor canal block (ACB), provide effective and synergistic pain relief when used as part of a multimodal regimen and provide the opioid-sparing effect [2].

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In particular, ACB is a relatively new alternative that provides pure sensory blockade with minimal effect on the quadriceps, with respect to quadriceps strength, pain control, ambulation ability, and complications, compared to femoral nerve block [2,3].

As the concept of fast-track total knee arthroplasty (TKA) has emerged [4], interests of the ideal analgesia regime that balances optimal postoperative pain control and early mobilization by preserving motor function were raised [2]. Several randomized controlled trials and meta-analyses have provided strong evidence that ACB resulted in significantly less quadriceps weakness and earlier functional recovery. ACB has been suggested as an effective alternative to femoral nerve block (FNB) for post-TKA patients because of similar analgesia and opioid consumption without increasing the incidence of complications compared to FNB [5–8].

Multiple afferent sensory nerves (e.g., saphenous nerve, medial femoral cutaneous, and medial retinacular nerve) are contained in an adductor canal and innervated at the anteromedial aspects of the knee joint, extending proximal tibia [9–11]. Therefore, ACB might have a more predominant effect on medial open-wedge HTO than TKA. However, to the best of our knowledge, the effect of ACB in medial open-wedge HTO has not been investigated in a clinical setting.

The objective of this study was to evaluate the clinical availability of ACB with regard to early period pain levels and range of motion (ROM), need for additional opioids, quadriceps strength (the time to straight leg raising [SLR]), and functional scores in patients who underwent medial open-wedge HTO. It was hypothesized that ACB would provide a sufficient pre-dominant analgesic efficacy with safety for medial open-wedge HTO.

2. Materials and methods

From August 2017 to April 2019, a total of 40 patients who underwent unilateral open-wedge HTO were enrolled. Indications for HTO were: (1) medial tibiofemoral OA with varus malalignment greater than 5° (measured on preoperative double-limb standing radiography); (2) near-normal ROM (flexion $>90^\circ$ and flexion contracture $<5^\circ$) [12]; and (3) desire for a high postoperative activity level. All patients were clinically followed up for ≥ 1 year. Forty patients were randomly assigned to either the single-shot ACB group ($n = 20$) or the placebo group ($n = 20$) on the day of surgery based on permuted block randomization [13] (Figure 1). 35 patients (4 males and 31 females) who were scheduled for unilateral open-wedge HTO, were prospectively randomized into the single-shot ACB group ($n = 19$; mean age: 55.9 ± 4.2 years) and the placebo group ($n = 16$; mean age: 55.7 ± 5.8 years). The mean follow-up period was 20.3 months. Both groups showed no significant differences in demographic characteristics of age, sex, and BMI (25.1 ± 1.9 in the ACB group, 25.6 ± 1.5 in the placebo group).

Approval was obtained from the Institutional Review Board (GCIRB2017-229) of our institution (Gachon University Gil Hospital, Incheon, South Korea) before the study, and the protocol was approved. All patients provided informed consent prior to participation in this study. Patients were eligible if they were scheduled for a primary open-wedge HTO with a participating surgeon and a planned use of regional anesthesia and were aged 40–70 years. Exclusion criteria included hepatic or renal insufficiency; chronic opioid, gabapentin, or pregabalin use (chronic defined as regular use for >3 months prior to the surgical procedure); diabetes; allergy; or intolerance to trial medications.

ACB was applied to all patients immediately before operation using the technique described by Jenstrup et al. [14]. A high-frequency linear ultrasound transducer was placed horizontally at the mid-thigh level (approximately halfway between the anterior superior iliac spine and the patella). A 10 cm, 18-gauge needle was introduced in the plane through the sartorius muscle. The correct position for the needle tip in the adductor canal was checked with a single injection of 20 mL *Chirocaine*. All blocks were applied by a senior anesthesia specialist experienced in sono-guided nerve blocks. The anesthesiologist was aware of the group assignments and patients were not blinded, whereas the study research assistants and patient care team were blinded. The randomization schedule and envelopes were prepared by a research assistant who was not otherwise involved in the trial.

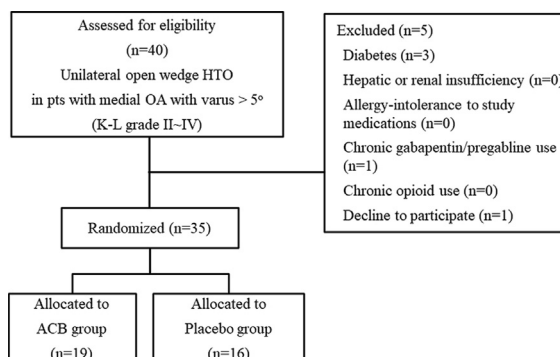


Figure 1. Consolidated Standards of Reporting Trials (CONSORT) diagram of patient flow through the study. ACB: adductor canal block; HTO: high tibial osteotomy.

Baseline information collected preoperatively included age, sex, body mass index, ASA physical status, and NRS for pain. Postoperative data collected on POD 12 h, 72 h, 2 weeks, and 3 months included NRS pain scores at rest, opioid consumption, and SLR.

All patients received medications for the multimodal analgesia protocol, including acetaminophen (1 g every 8 h for 72 h), celecoxib (200 mg every 12 h for 72 h), and oxycodone (given as needed every 4–6 h; oxycodone dose was given based on the reported pain score by the patient). All patients underwent prophylaxis treatment for postoperative nausea and vomiting during surgery. The protocol for prophylaxis against postoperative nausea and vomiting included the administration of 4 mg dexamethasone after induction of anesthesia and 4 mg ondansetron 20 min before recovery from anesthesia.

Quadriceps strength was evaluated using a manual 5-grade muscle strength scale (grades 0–5). Manual muscle testing was performed with patients in the sitting position. Patients were asked to extend their knee against gravity from a flexed position. If they were able to extend the knee to full extension against gravity, the muscle strength was scored as grade 3/5; if they were able to hold the knee in extension against resistance, it was scored as 5/5; and if they were unable to generate any contraction, it was scored as 0/5. Grades 0, 1, and 2 were based on the patients' capacity to move a limb (gravity eliminated) throughout the ROM.

2.1. Statistical analysis

A priori power analysis was performed to determine the sample size using the two-sided hypothesis test at an α level of 0.05 and a power of 0.8. A post-hoc power analysis was performed to determine whether the results of our study on 15 cases indicated adequate power, and the power was 85.21%, which was adequate to detect a difference of 1 mm VAS scales [15,16]. Statistical analyses were conducted using SPSS v22.0 software (IBM, Chicago, IL, USA). The conformity of data to normal distribution was tested using the Kolmogorov-Smirnov test. An independent two-sample *t*-test was used for the comparison of continuous variables, and the Pearson chi-square test was used for the comparison of categorical variables. Results were evaluated at a confidence interval of 95% and significance level of $p < 0.05$.

3. Results

Postoperative mean pain scores for both groups are shown in Figure 2. The pain score was lower in the ACB group than in the placebo group in the first 12 h ($p = 0.04$), but the differences between the groups were not significant after 12 h. ACB did not significantly lower the quadriceps strength at 72 h, 2 weeks, and 3 months postoperatively. There was no statistical difference in the time to SLR (23.5 ± 17.7 h in ACB vs. 27.6 ± 11.4 in placebo, $p = 0.520$) (Table 1). However, the opioid consumption rate within postoperative 12 h was significantly decreased in the ACB group (16.7% in ACB, 70% in placebo, $p = 0.017$). The proportion of patients with more than 5 opioid injections within 72 h postoperatively was lower in the ACB group (8.3% in ACB, 50% in placebo, $p = 0.043$) (Figure 3). Both groups did not show any localized complications, including neurologic sequelae, such as numbness and causalgia, hematoma and infection, or systemic complications, such as allergic reactions.

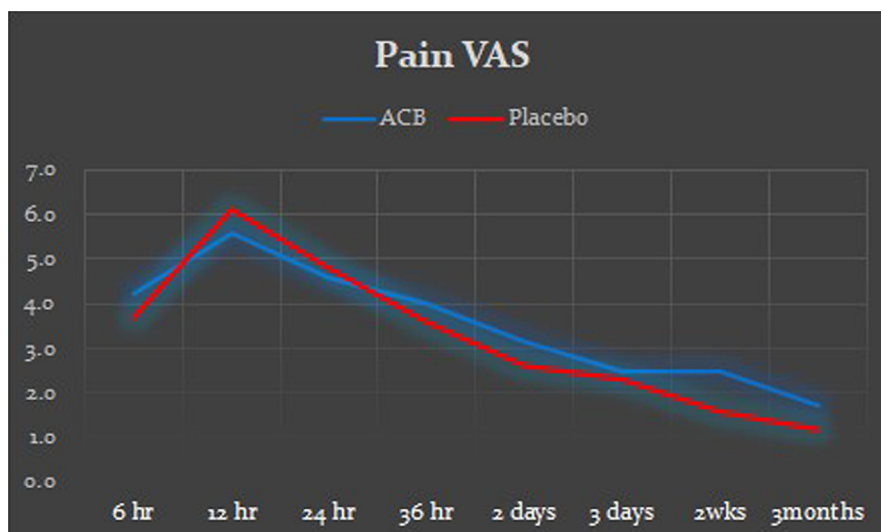
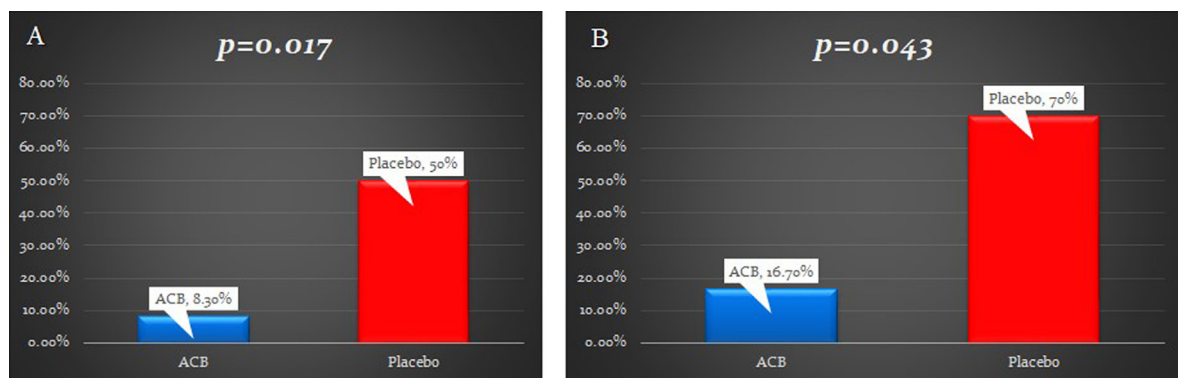


Figure 2. Time-based visual analog scale pain scores of patients according to the adductor block technique compared with the placebo group.

Table 1

Postoperative functional recovery results according to the adductor canal block technique

Mean (SD)	ACB group		Placebo group		p
Time to SLR (h)	23.5	(17.7)	27.6	(11.4)	0.520
SLR at 72 h	43.3	(31.0)	27.4	(21.6)	0.175
At 2 weeks	124.2	(71.8)	90.0	(25.4)	0.146
Muscle strength of the quadriceps (5-grade scale)					
At 72 h	4.0	(0.9)	4.0	(1.2)	1.000
At 2 weeks	4.7	(0.5)	4.5	(0.7)	0.471
At 3 months	5.0	(0)	5.0	(0)	
ROM (postoperative)					
At 72 h	103.3	(16.6)	101.6	(27.5)	0.807
At 2 weeks	108.0	(14.2)	115.0	(8.0)	0.271
At 3 months	126.5	(6.7)	130.6	(13.7)	0.455
MFTA (°, varus) _ preop	7.5	(2.1)	7.1	(2.8)	0.744
_ postop	−2.6	(2.8)	−3.0	(2.0)	0.078
Knee score _ preop	58.3	(18.3)	59.4	(14.3)	0.911
_ postop	91.7	(16.0)	86.3	(6.9)	0.553

**Figure 3.** (A) Opioid consumption rate within postoperative 12 h (B) More than 5 opioid injections within the postoperative 72 h.

4. Discussion

According to our hypothesis, patients in the ACB group would have a greater pain relief at 12 h postoperatively. The pain relief effect can be identified by significantly decreased morphine requirements up to 36 h. The authors concluded that analgesic efficacy of ACB, i.e., complete sensory loss of the medial, anterior, and lateral aspects of the knee extending from the superior pole of the patella to the proximal tibia [9], may be a minor contributor to postoperative pain following medial open-wedge HTO. In addition, no noticeable quadriceps strength loss was observed for 3 months postoperatively.

For years, FNB has been considered as the main peripheral nerve block for postoperative analgesia following knee surgery [3,17]. However, FNB reduces the quadriceps muscle strength and has been associated with an increased risk of falls (after TKA [18]). Meanwhile, ACB facilitated early mobilization by protecting quadriceps strength and providing an analgesic effect in this study. Open-wedge HTO decreases the moment arm of the ground reaction force and further offloads the medial compartment of the knee [19], resulting in a subsequent decrease in cartilage degeneration in the medial compartment with proven clinical improvement of pain symptoms [20,21]. However, several authors have reported the acceleration of degenerative changes due to increased patellofemoral joint (PFJ) contact pressure [22] by increased Q angle, altered PFJ tracking [23], and unintended changes in the patellar height after OWHTO [24–28]. In particular, early postoperative quadriceps atrophy can deteriorate the cartilage status after OWHTO. In that sense, ACB would have another clinical benefit over FNB.

The adductor canal, also known as the subsartorial or Hunter canal, is an aponeurotic tunnel that begins at the apex of the femoral triangle and ends at the adductor hiatus, serving as a passageway for the major neurovascular bundle from the femoral triangle to the popliteal fossa. It is roofed by the vasto-adductor membrane, also known as the anteromedial intermuscular septum or the subsartorial fascia, which is a strong aponeurosis between the adductor muscles and the vastus

medialis muscle. It contains the femoral vessels, saphenous nerve, and nerve to the vastus medialis muscle [10,11]. Surgical procedures during HTO, including a 5-cm vertical incision over the center between the medial aspect of the tibial tuberosity and the posteromedial aspect of the tibia below the joint line, detachment of the pes anserinus from the tibia, separation of the distal portion of the superficial medial collateral ligament, and tibial osteotomy, were covered by saphenous nerve innervation. Therefore, we hypothesized that ACB would provide a sufficient predominant effect for medial open-wedge HTO.

To prevent localized complications, including neurologic sequelae, we emphasized the correct position for the needle tip to be in the adductor canal. Therefore, we suggest that all blocks should be applied by an experienced anesthesia specialist through sono-guided nerve blocks. With regard to the application of ACB, continuous infusion via catheter demonstrated better pain control with a single-shot ACB following TKA [29]. However, continuous infusion via catheters has a risk of developing a hematoma around the adductor canal injection site after catheter removal, which can subsequently lead to saphenous distribution neuropathy [30]. Therefore, we applied a single-shot ACB, which showed significant pain relief and decreased the opioid consumption effect during the early postoperative period.

The present study has several limitations. First, this study was progressed with the relatively small sample size. However, well-designed, prospectively randomized trial would mitigate such a potential bias. Second, patients enrolled in this study were with same race of South Korea, thereby such a huge sexual difference by regional characteristics [31]. Sexual difference of pain threshold can be a potential bias in this study. Second, Femoral nerve block (FNB) has been traditionally used as a part of multimodal analgesia strategy during knee surgeries in many comparative studies with ACB and FNB in knee surgeries [32]. However, this study did not show the clinical relevance of peripheral nerve block with comparing of ACB and FNB. Further clinical trials to compare ACB and FNB and show the clinical advantages of two modalities can be required. Nevertheless, the strengths of this study include the use of a randomized controlled trial design, various types of pharmaceutical analgesics, and strict protocolized interventions. In conclusion, ACB following MOWHTO exhibited better outcomes than a placebo with respect to opioid consumption with no changes in the quadriceps strength and complications.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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