

The Analgesic Effects of Proximal, Distal, or No Sciatic Nerve Block on Posterior Knee Pain after Total Knee Arthroplasty

A Double-blind Placebo-controlled Randomized Trial

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ABSTRACT

Background: The analgesic efficacy of sciatic nerve block (SNB) after total knee arthroplasty (TKA) is unclear. Proximal and distal SNB are each reported to provide posterior knee analgesia, whereas others suggest that posterior knee pain is not important after TKA. This prospective, randomized, double-blind, parallel-arm, placebo-controlled trial examined whether proximal or distal SNB provides superior analgesia in the posterior knee compared with no SNB after TKA.

Methods: Sixty patients undergoing TKA were randomized to single-shot SNB using either the infragluteal (*Proximal* group) or popliteal (*Distal* group) technique, or no SNB (*Placebo* group). All patients received spinal anesthesia and continuous-femoral nerve blockade. A blinded observer assessed posterior and anterior knee pain at 2, 4, 6, 8, 12, and 24 h postoperatively. The primary outcome was moderate-to-severe posterior knee pain at 4 h postoperatively; secondary outcomes included SNB procedural time, needle passes, and discomfort.

Results: Fifty-three patients were analyzed. The proportion of patients (*Proximal:Distal:Placebo*) who experienced moderate-to-severe posterior knee pain was 18%:22%:89% ($P < 0.00001$) at 2 h, 24%:28%:72% ($P < 0.01$) at 4 h, and 12%:17%:78% ($P = 0.00003$) at 6 h postoperatively. For the anterior knee, the proportion of patients reporting moderate-to-severe pain was 6%:11%:44% ($P = 0.02$) at 2 h, 6%:6%:39% ($P = 0.012$) at 4 h, and 12%:6%:44% ($P = 0.017$) at 6 h postoperatively. Moderate-to-severe pain did not differ between groups beyond 6 h. Both proximal and distal SNB reduced rest pain in the posterior and anterior knee up to 8 h postoperatively compared with no SNB. The popliteal technique required shorter procedural time, fewer needle passes, and produced less discomfort.

Conclusion: Proximal and distal SNB each reduce posterior and anterior knee pain after TKA compared with no SNB. (*ANESTHESIOLOGY* 2014; 121:1302-10)

THE analgesic efficacy of sciatic nerve blockade (SNB) in the setting of total knee arthroplasty (TKA) is unclear.^{1,2} Numerous techniques of providing effective analgesia to the posterior knee after TKA have been described, including perigluteal blockade of the proximal sciatic nerve,³ distal SNB at the level of the popliteal fossa,⁴ and even isolated tibial nerve block.⁵ Other investigators have suggested that pain emanating from the posterior knee is not clinically important after TKA,⁶⁻¹⁰ thus questioning the role of SNB altogether and advocating simpler alternatives, such as local anesthetic infiltration.^{9,10} It is not surprising that our current understanding of the innervation of the posterior knee is limited, based largely on a single anatomical description published over one-half of a century ago,¹¹ wherein the articular branches of the tibial and obturator nerves are reported to provide sensory afferents to the posterior knee, whereas

What We Already Know about This Topic

- Numerous regional techniques for providing effective analgesia to the posterior knee after total knee arthroplasty have been described, although some studies question the importance of pain from this region and hence the role of sciatic nerve block

What This Article Tells Us That Is New

- In a placebo-controlled trial of 60 patients undergoing total knee arthroplasty, both proximal and distal sciatic nerve block reduced rest pain in the posterior and anterior knee more effectively for up to 8 h postoperatively compared with no sciatic nerve block

articular branches of the femoral, saphenous, and common peroneal nerves reportedly provide sensory afferents to the anterior knee. This randomized-controlled trial aims to determine whether the addition of a proximal or distal SNB

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reduces posterior knee pain in the setting of multimodal analgesia and continuous femoral nerve blockade (CFNB). We hypothesized that SNB provides superior analgesia in the posterior knee compared with no SNB after TKA.

Materials and Methods

This single-center trial was approved by the University Health Network Research Ethics Board (Toronto, Ontario, Canada) and conducted at the Toronto Western Hospital, a University of Toronto-affiliated teaching hospital located in Toronto, Canada. This trial was not preregistered in a clinical trial registry. The Consolidated Standards of Reporting Trials guidelines were adhered to in the preparation of this study report.^{12,13}

Study Participants

Between July 27, 2011 and January 23, 2012, adult patients with American Society of Anesthesiologists classification status I to III scheduled for elective primary unilateral TKA using a standard anesthetic-analgesic regimen that combines spinal anesthesia, catheter-based CFNB, and single-shot SNB were actively recruited for participation in this prospective, randomized, double-blind, parallel-arm, placebo-controlled, superiority clinical trial. On the basis of the surgical booking information available in advance, patients were recruited for study participation at the time of their preadmission visit approximately 1 month before the day of surgery. Eligible patients were interviewed and provided with a printed information package outlining the purpose of the study. Patients who could not be interviewed during their preadmission visit were approached for study participation on the day of surgery. Exclusion criteria included age less than 18 or more than 80 yr; body mass index greater than 35 kg/m²; pregnancy; inability to provide informed consent; cognitive or psychiatric history that may interfere in assessment; refusal of spinal, femoral, or sciatic blocks; local skin infection; allergy to local anesthetics or a component of the multimodal analgesia; preexisting neuropathy or neurological deficit in the lower extremities; preexisting chronic pain or other conditions requiring prolonged use of 30 mg of oxycodone or equivalent daily; and contraindication(s) to peripheral or central nerve blocks such as coagulopathy or bleeding diathesis.

After obtaining written informed consent, a diagram and a scripted dialogue were used to educate study participants about the surface anatomy of the anterior and posterior knee; light touch was used to demonstrate the difference between sensations arising from the anterior knee area (corresponding to the femoral nerve innervation) and those arising from the posterior knee area (corresponding to sciatic nerve innervation).¹⁴ A computer-generated sequence of random numbers was used to randomize the study participants on a 1:1:1 ratio with no restrictions to receive an ultrasound-guided SNB at the infragluteal level (*Proximal*

group), popliteal level (*Distal* group), or sham injection (*Placebo* group). The randomization sequence was generated by an investigator who had no further involvement in the study using Random Allocation Software 2.0[®] (Isfahan University of Medical Sciences, Isfahan, Iran) to generate lists of random numbers in varying blocks of four and six. The allocation was concealed in sealed opaque sequentially numbered envelopes kept by the research assistant. For each study participant, one envelope was handed to the attending regional anesthesiologist or supervised regional anesthesia fellow who was assigned to the block procedure room on the day of surgery and set to perform all nerve blocks required for the current study.

Sciatic Nerve Block

Standard monitoring including electrocardiograph, pulse oximetry, and noninvasive blood pressure were applied upon arrival to the block room. Intravenous (IV) access was established and midazolam 1 to 2 mg IV given as needed for anxiolysis. Regardless of group allocation, the skin in both infragluteal and popliteal areas was sterilized using chlorhexidine 2% swabs.

Proximal Group

Patients allocated to the *Proximal* group were placed in the lateral decubitus position with the surgical side up. The ultrasound-guided infragluteal approach to SNB was performed according to the technique originally described by Chan *et al.*³ A curvilinear 2 to 5 MHz ultrasound transducer (M-Turbo[®]; SonoSite Inc., Bothell, WA) was used to visualize the proximal sciatic in short-axis at the level of the ischial tuberosity medially and the greater trochanter laterally. A local skin wheal was created using 1 to 2 ml of lidocaine 1%. An 80-mm 22-gauge insulated needle (Stimuplex[®]; B. Braun Medical, Bethlehem, PA) was inserted out-of-plane relative to the ultrasound beam toward the nerve, through the anterior fascia of the gluteus maximus muscle. Hydrolocation by injecting 0.5 to 1 ml of dextrose 5% in water was used to localize the needle tip and advance it to the vicinity of the posterior external surface of sciatic nerve. A nerve stimulator (Stimuplex[®]; B. Braun Medical) was used to confirm the identity of the sciatic nerve. Thirty milliliter of a 2:1 admixture of bupivacaine 0.5%:lidocaine 2% with 1:200,000 epinephrine, delivered in 5 ml aliquots after negative aspiration for blood, was injected to achieve circumferential spread around the sciatic nerve as the sonographic endpoint for injection. To maintain blinding, patients in this group were subsequently placed prone and received a subcutaneous injection of 1 ml sterile saline solution in the popliteal fossa once the proximal SNB had been completed. Ultrasound was used to visualize the distal sciatic nerve and to simulate the pressure and block duration associated with the popliteal approach to SNB.

Distal Group

Patients allocated to the *Distal* group were placed in the prone position. The ultrasound-guided popliteal approach to SNB was performed according to the technique originally described by Sinha *et al.*⁴ A linear 6- to 13-MHz ultrasound transducer (M-Turbo®; SonoSite Inc.) was used to visualize the distal sciatic nerve in short-axis view at the level of the popliteal fossa; it was then traced proximally and block of the sciatic nerve was performed immediately proximal to its bifurcation into common peroneal and tibial nerves. A local skin wheal was created using 1 to 2 ml of lidocaine 1%. A 50-mm 22-gauge insulated needle (Stimuplex®; B. Braun Medical) was inserted out-of-plane relative to the ultrasound beam toward the nerve, through the anterior fascia of the biceps femoris muscle. Hydrolocation by injecting 0.5 to 1 ml of dextrose 5% in water was used to localize the needle tip and advance it to the vicinity of the posterior external surface of sciatic nerve. A nerve stimulator (Stimuplex®; B. Braun Medical) was used to confirm the identity of the sciatic nerve. Thirty milliliter of a 2:1 admixture of bupivacaine 0.5%:lidocaine 2% with 1:200,000 epinephrine, delivered in 5 ml aliquots after negative aspiration for blood, was injected to achieve circumferential spread around the sciatic nerve as the sonographic endpoint for injection. To maintain blinding, patients in this group were subsequently placed in the lateral decubitus position and received a subcutaneous injection of 1 ml sterile saline solution in the infragluteal region once the distal SNB block has been completed. Ultrasound was used to visualize the proximal sciatic nerve and to simulate the pressure and block duration associated with the infragluteal approach to SNB.

Placebo Group

Patients allocated to the *Placebo* group received two subcutaneous injections of 1 ml sterile saline solution: one in the infragluteal region while positioned laterally, and one in the popliteal region while positioned prone. Ultrasound was used to visualize the sciatic nerve and to simulate the pressure and block duration associated with the infragluteal and popliteal approaches to SNB, respectively. During the sham procedures, an unblinded research assistant shook the patient's foot to mimic a nerve stimulator response to sciatic nerve stimulation, as described previously.¹⁵

After SNB, all patients were positioned supine, and a CFNB was inserted under ultrasound-guidance as described previously.¹⁶ Once the catheter was secured in place, all patients received 10 ml mepivacaine 2% injected through the CFNB catheter.

Block Assessment

We assessed all patients for evidence of sensory blockade (sensation to pinprick) in the corresponding dermatomes before transfer from the block procedure room to the operating theatre. For the purposes of the current study, any patient who did not demonstrate clinical evidence of sensory

blockade in both the femoral and sciatic (except the *Placebo* group) nerve distributions before transfer to the operating theatre was excluded from the study. Once block assessment was completed, all patients received spinal anesthesia in the sitting position with 2.5 to 3.0 ml isobaric bupivacaine 0.5% and 100 µg preservative-free morphine.

Intraoperative Care

All patients received sedation with midazolam 1 to 2 mg IV and/or propofol infusion 12.5 to 50 µg kg⁻¹ min⁻¹ as needed during surgery, at the discretion of the anesthesiologist providing intraoperative care who was blinded to group allocation. All additional medications administered during surgery were documented. A lower limb tourniquet was applied in the mid-thigh.

Postoperative Clinical Pathway

Postoperatively, our institution's clinical pathway for TKA was initiated, as follows:

Upon arrival in the postanesthesia care unit (PACU), all patients received a bolus of 20 ml of ropivacaine 0.2% with epinephrine 1:400,000 injected through the CFNB catheter. An infusion of ropivacaine 0.2% was also initiated through the CFNB catheter with a baseline rate of 5 ml/h and patient-controlled boluses of 5 ml available every 30 min. Fentanyl 25 µg IV increments were administered every 5 to 10 min as needed for rescue analgesia in the PACU, up to a total of 200 µg/h, administered by the PACU nursing staff.

The standardized postoperative multimodal analgesic regimen for all patients included: celecoxib 200 mg every 12 h (100 mg if weight less than 70 kg or age greater than 65 yr), or alternatively 15 mg meloxicam daily (7.5 mg if age greater than 65 yr) if allergic to sulpha; acetaminophen 1 g every 6 h; oxycodone-controlled release 10 mg every 8 h (5 mg if age greater than 65 yr); and patient-controlled oral oxycodone immediate release 10 mg (5 mg if age greater than 65 yr) every 2 h as needed. The acute pain service assessed all patients twice daily. If pain control was inadequate (numerical rating scale [NRS] ≥7), the acute pain service sequentially increased the dose of oral opioids, initiated IV hydromorphone patient-controlled analgesia, and/or injected a local anesthetic bolus through the femoral catheter, as appropriate. Patients were mobilized on the morning of postoperative day 1 at the discretion of the physiotherapists assigned to the orthopedic ward. The CFNB local anesthetic infusion was discontinued at 6:00 AM on postoperative day 2.

Follow-up

All study participants received a scripted telephone call from a blinded research assistant at 1 week postoperatively to inquire about pain severity and localization, as well as occurrence of any new block-related complications. If any new sensory or motor deficits were reported, arrangements were made for continued follow-up until symptoms resolved.

Outcome Measures

Apart from the number of needle passes, which were reported by an independent observer, and confirmation of block onset, which was reported by the attending regional anesthesiologist or regional anesthesia fellow in the block procedure room, all outcome data were collected by a research assistants blinded to group allocation.

The proportion of patients experiencing moderate-to-severe posterior knee pain, defined as pain severity score of 4 or greater on an NRS (0 = no pain, 10 = worst pain) that is refractory to CFNB, at 4 h after TKA was designated as the primary outcome. The 4-h postoperative time point was selected to ensure the complete resolution of the spinal anesthetic that was administered before surgical incision.^{17,18}

Secondary procedure-related (for treatment SNB only) outcomes included: (1) SNB procedure time, defined as the interval between the ultrasound probe contact with patient's skin and needle withdrawal from the skin after injection of local anesthetics¹⁹; (2) number of needle passes, defined as deliberate needle tip withdrawal to skin level or additional skin puncture; (3) SNB procedural pain, reported by study participants upon SNB completion; (4) dose of sedatives administered during SNB; and (5) incidence of SNB complications, including intravascular injection, local anesthetic systemic toxicity, vascular puncture, formation of hematoma, transient and prolonged (duration ≥ 1 month) paresthesiae.

Analgesic outcomes assessed included the following: (1) severity of pain (NRS) in the posterior knee at rest and with movement (knee flexion) upon admission to PACU and at 2, 4, 6, 8, 12, and 24 h and 7 days postoperatively; (2) severity (NRS) of pain in the anterior knee at rest and with movement (knee flexion) upon admission to PACU and at 2, 4, 6, 8, 12, and 24 h and 7 days postoperatively; (3) the time (minutes) to first analgesic request after admission to PACU, defined as the interval between the end of injection of the spinal anesthetic and first postoperative request for analgesia; (4) the cumulative analgesic consumption (converted to oral morphine equivalent)²⁰ during PACU stay and at 24 h; and (5) incidence of postoperative nausea and vomiting during the first 24 h.

Statistical Analysis

Ben-David *et al*²¹ reported that 75% of patients undergoing unilateral TKA experienced pain refractory to femoral nerve block; 100% of those patients described relief when a sciatic block was administered. This corresponds to a huge size effect attributable to sciatic block. In our power analysis, we used a more conservative²² estimate of the impact of SNB on posterior knee pain reflecting small change, or a corresponding size effect equivalent to an odds ratio of 1.25 to test the superiority of SNB.

Assuming that SNB increases the proportion of patients free from postoperative rest pain localized to the posterior knee by a size effect of 1.25 compared with placebo, we calculated that 51 patients (17 patients per group) would

be required to detect a statistically significant difference between groups with α of 0.05 and 90% power. Allowing a 15% loss due to patient drop out or incomplete follow up, we planned to recruit a total of 60 patients.

The SPSS statistical package for Windows (version 22; SPSS Inc., Chicago, IL) was used to perform the analysis. Calculations were performed under the assumptions that (1) study groups are independent; (2) data within the study groups are normally distributed; and (3) within group variances are equal. We tested the normality of data distribution using the Shapiro–Wilk test. For continuous data, we used a one-way ANOVA and performed *post hoc* testing using the *t* test. For categorical data, we used a contingency table with Fisher exact test and performed *post hoc* testing using the Mann–Whitney U test. For ordinal data, we used the Kruskal–Wallis test and performed *post hoc* testing using the Mann–Whitney U test. The *P* value threshold for statistical significance was calculated using the Bonferroni method to adjust for multiple comparisons among groups. The *P* values for repeated measurement of pain NRS scores were corrected using the Bonferroni–Holm²³ adjustment for repeated comparisons. Continuous data are presented as mean (SD) or mean (95% CI); categorical data are presented as numbers or percentages.

Results

Sixty patients were randomized, of which 53 (*Proximal* group *n* = 17, *Distal* group *n* = 18, and *Placebo* group *n* = 18) completed the study protocol (fig. 1). At the discretion of the attending regional anesthesiologist, a total of seven patients (*Proximal*, 3; *Distal*, 2; *Placebo*, 2) did not receive the study interventions (*i.e.*, SNB or placebo) due to time constraints in the block procedure room and/or operating theatre; these seven patients were excluded from the study. Block assessment revealed evidence of sensory block in both the femoral and sciatic (active groups) nerve distributions for all patients. The characteristics of study participants were similar for the three study groups. (table 1)

The proportion of patients in the three study groups (*Proximal:Distal:Placebo*) who experienced moderate-to-severe posterior knee pain were 18%:22%:89% at 2 h ($P < 0.00001$), 24%:28%:72% at 4 h ($P < 0.01$), and 12%:17%:78% at 6 h ($P = 0.00003$) postoperatively. (fig. 2) This proportion did not differ between groups beyond 6 h postoperatively. The proportion of patients in the three study groups (*Proximal:Distal:Placebo*) who experienced moderate-to-severe anterior knee pain were 6%:11%:44% at 2 h ($P = 0.02$), 6%:6%:39% at 4 h ($P = 0.012$), and 12%:6%:44% at 6 h ($P = 0.017$) postoperatively. This proportion did not differ between groups beyond 6 h postoperatively.

The SNB in the *Distal* group required less time to perform, required fewer needle passes, caused less patient discomfort, and required smaller doses of midazolam for procedural sedation (table 2). SNB-related complications

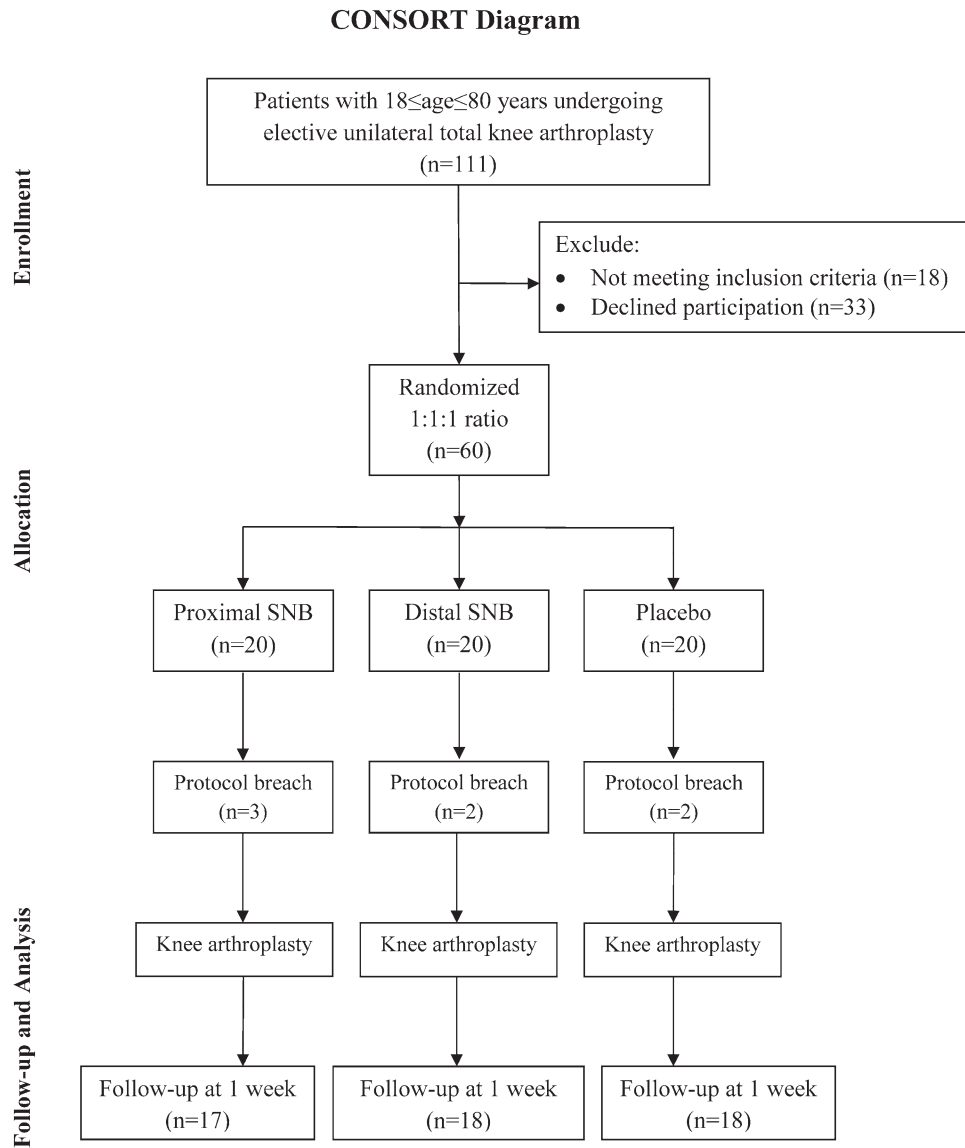


Fig. 1. Consolidated Standards of Reporting Trials (CONSORT) flow diagram showing patient progress through the study phases. SNB = sciatic nerve block.

Table 1. Patient Characteristics

Parameter	Proximal Group (n = 17)	Distal Group (n = 18)	Placebo Group (n = 18)
Age (yr)	64.7 (62.4–67.0)	65.1 (59.2–71.0)	63.2 (61.1–65.3)
Sex (F/M)	12/5	13/5	10/8
Height (cm)	159.4 (157.5–161.3)	163.7 (157.8–169.6)	162.3 (159.2–165.4)
Weight (kg)	82.3 (75.6–89.0)	78.8 (71.3–86.3)	79.6 (66.4–92.8)
Surgical side (R/L)	7/10	10/8	9/9
Duration of surgery	87.7 (81.6–93.8)	91.8 (82.5–101.1)	86.4 (78.2–94.6)
ASA status (II/III)	13/17	12/18	14/18

Values are expressed as the mean (95% CI) or absolute numbers.

ASA = American Society of Anesthesiologists; F = female; L = left; M = male; R = right.

were not observed in any of the patients during block performance. None of the patients reported prolonged paresthesiae; but two patients in the *Proximal* group and one in

the *Distal* group reported transient paresthesiae in the distribution of the sciatic nerve when contacted at 7 days that resolved spontaneously within 1 month of surgery.

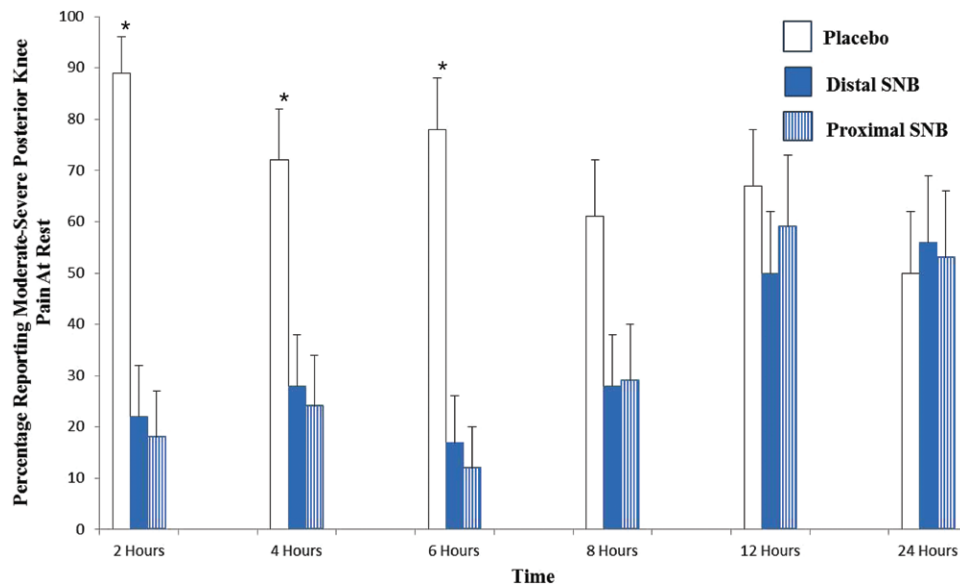


Fig. 2. Bar graph representing proportions of patients experiencing moderate-to-severe posterior knee pain at rest during the first 24 h after total knee arthroplasty. * Statistically significant difference. SNB = sciatic nerve block.

Table 2. Procedure-related and Analgesic Outcomes Results

Outcome	Proximal Group (n = 17)	Distal Group (n = 18)	Placebo Group (n = 18)	P Value for Group Effect
Block procedure time (min)	8.7 ± 2.14	5.68 ± 1.19	N/A	<0.00001*
Number of needle passes	2 (1–4)	1 (1–2)	N/A	0.016*
Procedural pain NRS score during sciatic block	2.57 ± 1.51	1.37 ± 1.08	N/A	0.01*
Midazolam requirements during sciatic block (mg)	2.14 ± 0.77	1.96 ± 0.66	N/A	0.46*
Time to first analgesic request (min)	184.92 ± 27.64	193.66 ± 29.88	157.12 ± 19.53	<0.0001†
Cumulative PACU oral morphine equivalent consumption (mg)	17.65 ± 8.36	16.44 ± 6.17	28.37 ± 12.89	0.001†
Cumulative 24-h oral morphine equivalent consumption (mg)	131.14 ± 19.21	127.72 ± 33.85	167.46 ± 59.54	0.01†
Proportion of patients requiring IV PCA	1/17	0/18	0/18	1.0†
Incidence of PONV during first 24 h	5/17	4/18	13/18	0.005†
Incidence of paresthesiae on day 7	2/17	1/18	N/A	0.52*

Values are expressed as the mean ± SD, median (range), or absolute numbers.

* The Bonferroni corrected *P* value for the Proximal vs. Distal SNB comparison is set at 0.017. † The *P* value for the overall *F* test and the Fisher exact test is set at 0.05.

IV PCA = intravenous patient-controlled analgesia; N/A = not applicable; NRS = numerical rating scale; PACU = postanesthesia care unit; PONV = postoperative nausea and vomiting.

Patients in the *Proximal* and *Distal* groups each reported reduced pain at rest in the posterior knee as well as in the anterior knee up to 8 h postoperatively compared with the *Placebo* group; however, no differences in rest pain were observed between the *Proximal* and *Distal* groups. (fig. 3, A and B) Additionally, patients in the *Proximal* and *Distal* groups each reported less dynamic pain in the posterior knee as well as in the anterior knee up to 6 h postoperatively compared with the *Placebo* group; however, no differences in dynamic pain were observed between the *Proximal* and *Distal* groups. (fig. 4, A and B) Furthermore, the time to first analgesic request, cumulative oral morphine equivalent consumption in PACU and at 24 h, as well as incidence of postoperative nausea and vomiting were reduced in both the *Proximal* and *Distal* groups compared with the *Placebo* group; however, no such differences were observed between

the *Proximal* and *Distal* groups (table 2). Finally, the requirement for IV patient-controlled analgesia was similar between study groups.

Discussion

This is the first randomized-controlled trial to demonstrate that adding SNB to a femoral nerve block reduces posterior knee pain after TKA. Our findings suggest that proximal and distal SNB can each provide superior analgesia after TKA compared with no SNB in the setting of multimodal analgesia and CFNB. Compared with placebo, both approaches to SNB reduced the proportion of patients experiencing moderate-to-severe posterior and anterior knee pain, decreased posterior knee pain as well as anterior knee pain at rest and with movement, reduced opioid consumption and opioid-related side effects, and prolonged

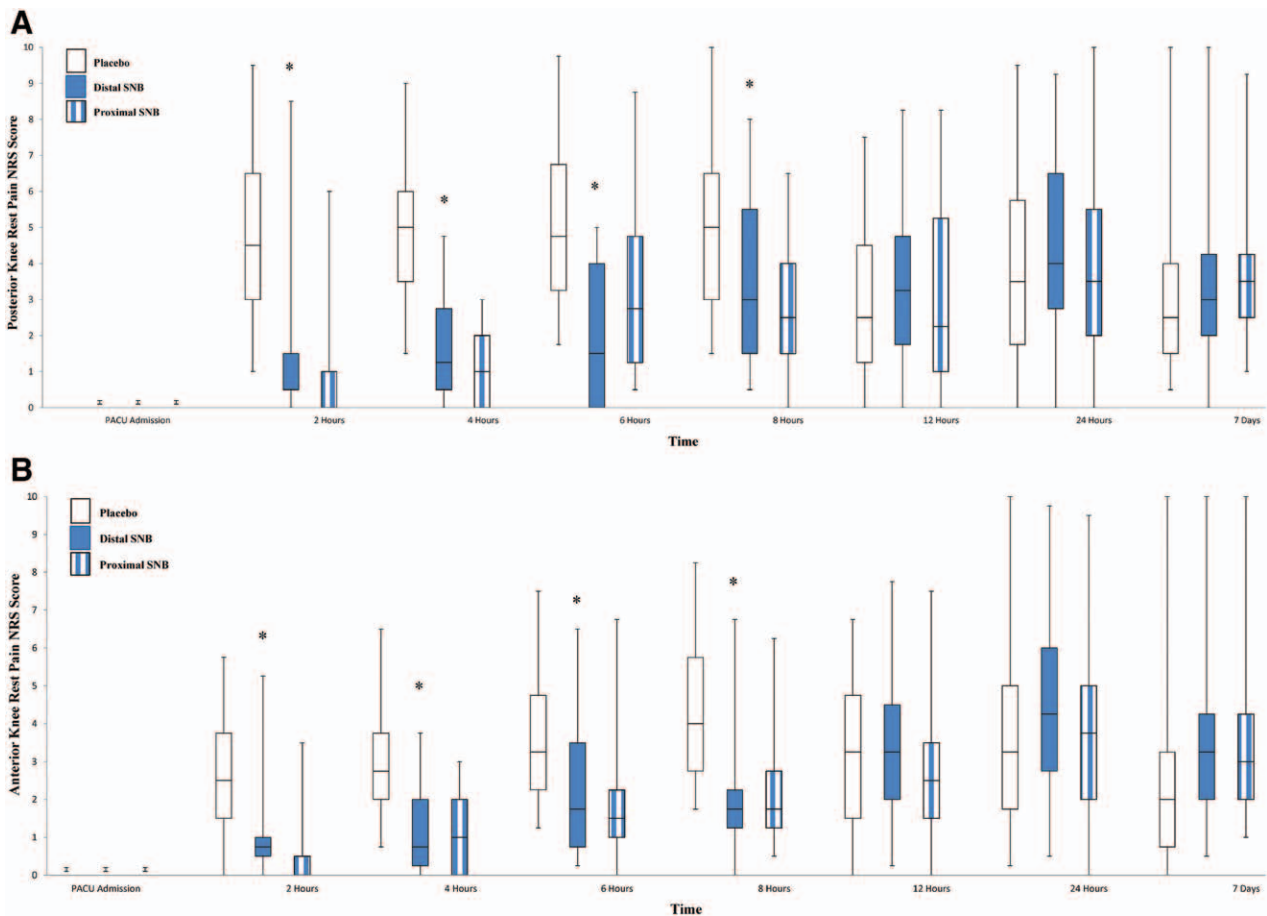


Fig. 3. Box plots of postoperative rest pain scores of the (A) posterior and (B) anterior knee in each group during the first week after total knee arthroplasty. * Statistically significant difference between the three study groups. NRS = numerical rating scale; PACU = postanesthesia care unit; SNB = sciatic nerve block.

the time to first analgesic request. Importantly, regardless of approach, SNB can reduce the severity of anterior knee pain within the context of CFNB, a finding that may be explained by the partial innervation of the lateral and antero-lateral knee by the common peroneal nerve articular branches.^{11,24} Last, our results provide clinical evidence that the sciatic nerve branches involved in knee innervation are distal enough to be collectively blocked by local anesthetic injection proximal to the sciatic nerve bifurcation in the popliteal fossa. Because the distal approach to SNB was faster to perform, required fewer needle passes, and produced less patient discomfort, an ultrasound-guided popliteal block may be more attractive than an infraglutal technique for patients undergoing TKA.

There are several limitations related to the current study. First, our present results pertain only to the setting of multimodal analgesia and CFNB, and are not generalizable to other postoperative analgesic regimens after TKA. Similarly, the procedure-related advantages demonstrated with ultrasound-guided SNB at the popliteal level compared with the infraglutal level may not be generalizable to other methods of nerve localization, such as nerve stimulation. Although our results signal that longer may be better,

strategies to prolong the effective duration of SNB beyond the observed 6 to 8 h postoperatively, such as local anesthetic adjuvants^{25,26} or catheter-based infusion,^{7,21,27–29} must be carefully balanced against the potential for delayed mobilization and masking of intraoperative iatrogenic peroneal nerve injury. Furthermore, our results depend to a large extent on the reliability of pain localization by the study participants and their ability to distinguish between and rate their pain arising from two distinct sources. Indeed, the mechanisms by which we perceive pain arising from distinct yet adjacent sources and their respective interactions, namely spatial summation³⁰ and discrimination,³¹ render this task challenging. The phenomenon of spatial summation of pain suggests that the interaction of excitatory and inhibitory stimuli may lead to peculiar scenarios where an increase in the area of painful stimuli does not necessarily translate into an increase in the pain perceived.³² The phenomenon of spatial discrimination of pain suggests a profound limitation in perceiving pain arising from two distinct sources when these are less than 10 cm apart for the arm,³³ or 15 cm apart for the leg.³⁴ One or both of these phenomena may also at least partially account for the observed reduction in anterior knee pain associated with SNB in the context of the current study.

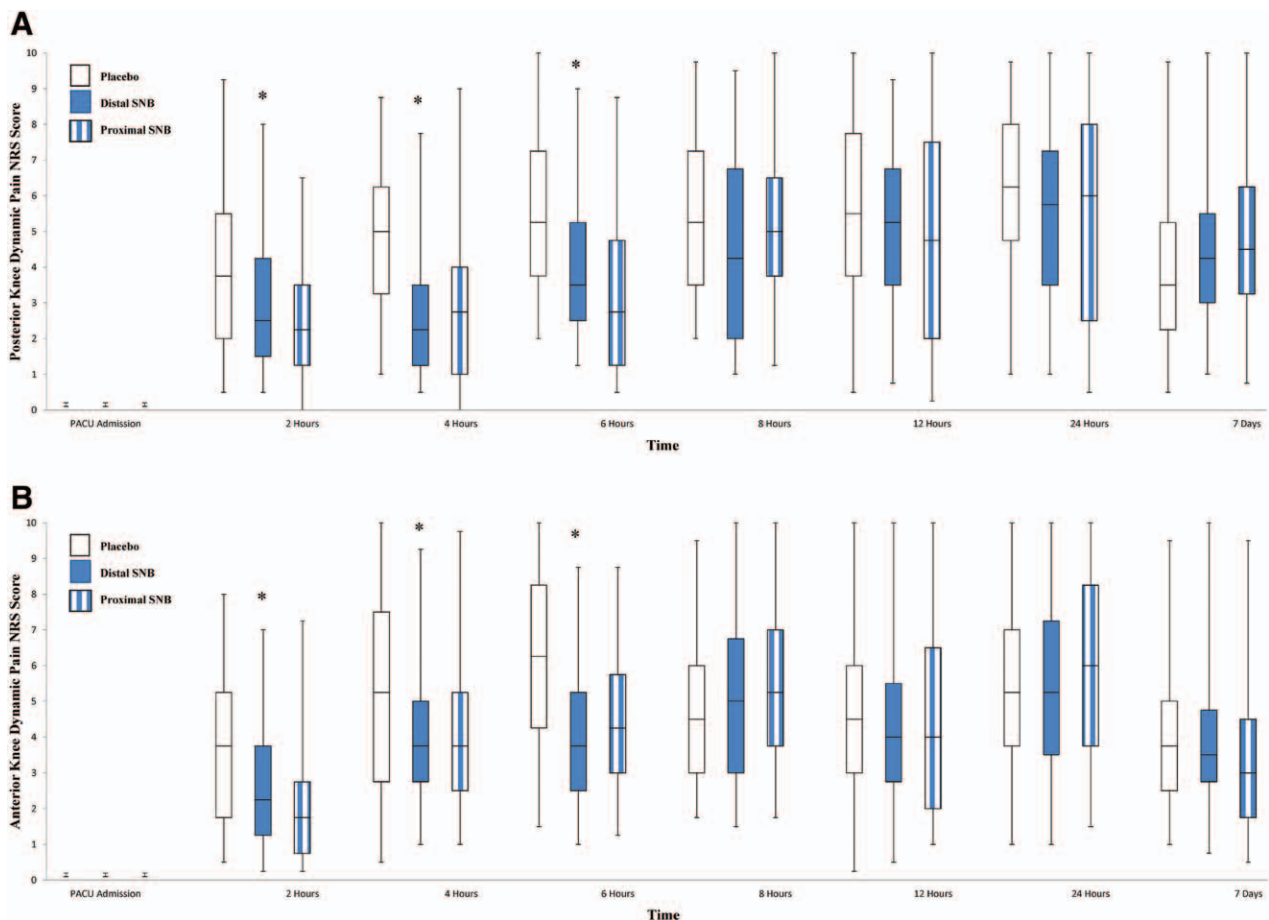


Fig. 4. Box plots of postoperative dynamic pain scores of the (A) posterior and (B) anterior knee in each group during the first week after total knee arthroplasty. * Statistically significant difference between the three study groups. NRS = numerical rating scale; PACU = postanesthesia care unit; SNB = sciatic nerve block.

In addition, our multimodal analgesic regimen may have inadvertently concealed the true severity of posterior knee pain. We also did not attempt to examine the contribution of the obturator nerve to postoperative knee pain. Indeed, the residual posterior knee pain observed despite SNB may be explained by the partial innervation of the posterior knee by the obturator nerve.^{35,36} Finally, we cannot exclude the introduction of bias stemming from inadvertent unblinding of subjects during the SNB procedure and/or postprocedure sensory block assessment as we did not evaluate the success of subject blinding *post hoc*. Nonetheless, although we recognize the potential for unblinding patients in the *Placebo* group within the context of the current study, we believe that the importance of confirming sensory block onset in the active SNB groups outweighs the risk of unblinding.

In conclusion, proximal and distal SNB can each significantly reduce posterior as well as anterior knee pain after TKA compared with no SNB in the setting of multimodal analgesia and CFNB. For SNB in patients undergoing TKA, the ultrasound-guided popliteal technique is faster and easier to perform and causes less patient discomfort than the infra-gluteal technique.

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Competing Interests

Dr. Chan receives equipment support from BK Medical (Wilmington, Massachusetts), Philips Medical Systems (Bothell, Washington), SonoSite (Bothell, Washington), and Ultrasonix (Richmond, British Columbia, Canada). The other authors declare no competing interests.

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