

Using Stimulating Catheters for Continuous Sciatic Nerve Block Shortens Onset Time of Surgical Block and Minimizes Postoperative Consumption of Pain Medication After Halux Valgus Repair as Compared with Conventional Nonstimulating Catheters

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We prospectively tested the hypothesis that the use of a stimulating catheter improves the efficacy of continuous posterior popliteal sciatic nerve block in 100 randomized patients scheduled for elective orthopedic foot surgery. After eliciting a sciatic mediated muscular twitch at ≤ 0.5 mA nerve stimulation output, the perineural catheter was advanced 2–4 cm beyond the tip of the introducer either blindly (Group C; $n = 50$) or stimulating via the catheter (Group S; $n = 50$). A bolus dose of 25 mL of 1.5% mepivacaine was followed by a postoperative patient-controlled infusion of 0.2% ropivacaine (basal infusion: 3 mL/h; incremental dose: 5 mL; lockout time: 30 min). Propacetamol 2 g IV was administered every 8 h, and opioid rescue analgesia was available if required. Catheter placement required 7 ± 2 min in Group S and 5 ± 2 min in

Group C ($P = 0.056$). A significantly shorter onset time of both sensory and motor blocks was noted in Group S. No difference in quality of pain relief at rest and during motion was reported between the groups. Median (range) local anesthetic consumption during the first 48 h after surgery was 239 mL (175–519 mL) and 322 mL (184–508 mL) in Groups S and C, respectively ($P = 0.002$). Rescue opioid analgesia was required by 12 (25%) and 28 (58%) patients in Groups S and C, respectively ($P = 0.002$). We conclude that the use of a stimulating catheter results in shorter onset time of posterior popliteal sciatic nerve block, similar pain relief with reduced postoperative consumption of local anesthetic solution, and less rescue opioid consumption.

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Continuous peripheral nerve blocks have become increasingly popular for both in- and outpatient orthopedic lower limb procedures because they provide better pain relief than IV opioids and similar analgesia with less side effects than epidural block (1–4). However, when a classical blind insertion technique is used, the final position of the catheter tip is not predictable and can be inadequate in 20%–50% of

cases (5). This unpredictable final position of the catheter can result in either failure of surgical block (primary block failure) or inadequate postoperative analgesia (secondary block failure).

Technological development has recently provided the anesthesiologist with stimulating catheters, which theoretically should allow catheter tip location closer to the nerves (6,7). Indeed, in a recent volunteer study involving continuous femoral nerve block, the use of such a catheter provided a significantly better tolerance to transcutaneous electrical stimulation and a more marked reduction of quadriceps motor strength than a traditional nonstimulating technique (8). However, the preliminary clinical studies failed to confirm such results (9,10). More comparative data are thus

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required to better evaluate the effectiveness of stimulating catheters.

The aim of this prospective, randomized, double-blind, multicenter investigation was to determine if the use of a stimulating catheter-guided technique can minimize the amount of local anesthetic solution requested by the patient during continuous posterior popliteal sciatic nerve block after elective orthopedic foot surgery.

Methods

After obtaining Institutional Ethical Committee approval and patients' written informed consent, 100 ASA physical status I-III patients, undergoing elective orthopedic foot surgery, including hallux valgus repair or foot procedures with major osteotomies under combined sciatic-femoral nerve block, were prospectively enrolled. Patients receiving chronic analgesic therapy, as well as those with contraindications to regional anesthesia, severe cardiopulmonary disease, thyroid disease, diabetes, and central or peripheral neuropathies were excluded.

After IV midazolam premedication (0.03 mg/kg), standard monitoring for noninvasive arterial blood pressure, electrocardiograph (lead II), heart rate, and oxygen saturation was placed. In each participating center, an experienced anesthesiologist performed all nerve blocks with the aid of a nerve stimulator (Plexygon, Vygon, France). The stimulation frequency was set at 2 Hz, pulse duration at 0.15 ms, and the initial intensity of stimulating current at 1 mA.

With the patient in the prone position, a posterior popliteal sciatic catheter (11) was placed using an 18-gauge, 85-mm-long stimulating needle over-sheathed with a plastic introducer (Multiplex, Vygon, France). After eliciting an adequate muscular twitch (i.e., plantar or dorsiflexion of the foot) with a current intensity ≤ 0.5 mA, the stimulating needle was removed and the introducer left in place. Using a computer-generated sequence of random numbers and a sealed envelope technique, patients were then divided into 2 groups of 50: in Group S, the catheter was inserted with nerve stimulation guidance. With a starting current output of 1.5 mA, the catheter was advanced 2-4 cm past the introducer tip while eliciting an adequate muscular twitch. Catheter position was judged adequate when the twitch was obtained with a stimulating current output ≤ 1 mA. If this twitch disappeared during insertion, the catheter was withdrawn until it reappeared. If this did not occur, the catheter was removed and the procedure repeated. In Group C, the catheter was inserted with the conventional nonstimulating technique (blind insertion) and advanced 2-4 cm beyond the introducer tip. In all patients, the catheter was secured in place using steri-strip and a transparent Tegaderm™ dressing. After a

negative aspiration test for blood, 25 mL of 1.5% mepivacaine was injected through the catheter.

The femoral nerve was blocked at the inguinal crease with 15 mL of 1.5% mepivacaine (12). The anesthesiologists and pain nurses managing the patients both during and after surgery were blinded to the technique used. The onset of sensory (loss of pinprick sensation) and motor (inability to move) blocks in the sciatic nerve distribution were evaluated every 5 min after the initial bolus injection by an independent blinded observer. The anesthesiologists, surgeons, and nurses taking care of studied patients during and after surgery were unaware of the technique used for block placement. If the block was not adequate for surgery after 30 min, it was considered as failed (primary block failure), and general anesthesia was administered. A pneumatic tourniquet was placed at the calf and inflated to a pressure of 100 mm Hg higher than the systolic arterial blood pressure. When required, IV sedation using a target-controlled infusion of propofol (target concentrations ranging between 1.0 and 1.5 $\mu\text{g}/\text{mL}$) or supplemental fentanyl was provided during the procedure. In all patients, the sciatic nerve block was maintained during the first 48 postoperative hours with a patient-controlled (PCA) infusion of 0.2% ropivacaine. Postoperative infusion of ropivacaine was started 3 h after the initial bolus and delivered a basal infusion rate of 3 mL/h and PCA incremental doses of 5 mL with a lockout time of 20 min and a maximum of 2 doses per hour (allowing a maximum hourly volume of 13 mL/h).

The degree of pain at rest and after asking the patient to move the operated foot was assessed using a 10 cm visual analog scale (VAS: 0 = no pain and 10 = unbearable pain) when starting the continuous sciatic infusion and then at 12, 24, and 48 h. Propacetamol 2 g IV was administered every 8 h, and opioid rescue analgesia (i.e., 100 mg of tramadol IV) was available to maintain a VAS score ≤ 4 cm.

If pain relief was not obtained (i.e., VAS > 4 cm) despite the use of the maximum available local anesthetic volume and rescue opioid analgesia, a 10 mL bolus of 1% mepivacaine was injected through the catheter to evaluate correct functioning of the block; if such injection was ineffective, the block was considered as failed (secondary failure) and the patient withdrawn from the study. Sensory (loss of pinprick sensation) and motor (use of a 2 point scale: 0 = persistent motor block, i.e., the patient was unable to move the ankle; 1 = recovery of motor function, i.e., the patient was able to flex and extend the ankle) block in both common peroneal and tibial nerve distributions was evaluated when the continuous sciatic infusion was initiated and then at 12, 24, and 48 h. Daily and total local anesthetic consumption, the number of incremental doses requested and given, supplemental tramadol, and the occurrence of side effects (such as

nausea and vomiting) during the study period were recorded. When the catheter was removed on the second postoperative day, the insertion site was examined, and patient satisfaction was evaluated using a 10-cm VAS (0 = not satisfied and 10 = totally satisfied).

The orthopedic surgeon evaluated neurological function 1 week after the procedure during the routine ambulatory visit.

To calculate the sample size, we considered results of a pilot study we performed evaluating the consumption of local anesthetic solution during the first 24 h of infusion using stimulating or nonstimulating catheters for continuous sciatic nerve block (unpublished observations; results of this pilot study were not included in the final data analysis). In this pilot study, we observed a mean (\pm SD) consumption of 0.2% ropivacaine of 134 ± 26 mL with a stimulating catheter and 148 ± 39 mL with a nonstimulating catheter. Based on this pilot study, 50 patients per group were required to detect a 25 mL difference in the volume of local anesthetic solution infused during the first 24 h of infusion between the two groups with an effect size to standard deviation ratio of 0.8 and accepting a two-tailed α error of 5% and a β error of 5%.¹³ This sample size also allowed us to detect a reduction in need for rescue pain medication from 55% to 25% with a two-tailed α error of 5% and a β error of 20%.¹³

Statistical analysis was performed using the program Systat 7.0 (SPSS Inc, Chicago, IL). After a "center-effect" was excluded, normal distribution of the collected data was first verified using the Kolmogorov-Smirnov test. Continuous variables were analyzed using unpaired Student's *t*-test or the Mann-Whitney *U*-test based on data distribution. The Bonferroni correction for multiple comparisons was also used if indicated. Categorical variables were analyzed using the contingency table analysis and Fisher's exact test. A value of $P \leq 0.05$ was considered as significant. Continuous variables are presented as mean (\pm SD) or median (range) according to data distribution, whereas categorical variables are presented as number (%).

Results

No differences in age, sex, weight, height, and ASA physical status were observed between the groups (Table 1).

Catheter placement required 7 ± 2 min in Group S and 5 ± 2 min in Group C ($P = 0.056$), whereas the minimum current intensity required to stimulate the sciatic nerve was 0.39 ± 0.17 and 0.38 ± 0.04 mA in Groups S (through the catheter) and C (through the stimulating needle), respectively ($P = 0.223$). In two patients (one in each group), adequate nerve block

Table 1. Anthropometric Characteristics

	Group S (n = 50)	Group C (n = 50)
Age (yr)	56 \pm 10	54 \pm 11
Weight (kg)	68 \pm 12	65 \pm 9
Height (cm)	164 \pm 7	161 \pm 20
Sex (M/F)	9/41	6/44

Data are presented as mean SD or count.

Table 2. Onset Time of Sensory and Motor Blocks

	Group S (n = 49)	Group C (n = 49)	P-value
Onset of sensory block (min)			
Tibial nerve	15(5-30)	20(5-35)	0.008
Common peroneal nerve	10(5-30)	15(5-30)	0.02
Motor block	20(5-40)	30(5-60)	0.004

Data are presented as median (range).

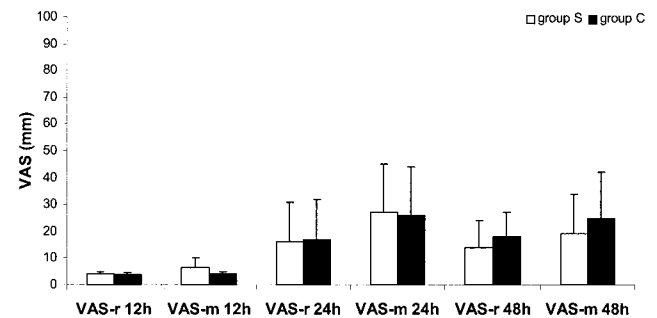


Figure 1. Pain scores (mean \pm SD) at rest (VAS-r) and after asking the patient to move the ankle joint (VAS-m) at 12, 24, and 48 h. Data are presented as mean \pm SD. The 48-h observation included only 34 and 32 patients in Groups C and S, respectively, because the other patients were discharged home before completing the 48-h observation period.

was not achieved within 30 min after the initial bolus. General anesthesia was induced, and patients were excluded from further data analysis. Table 2 shows the onset time of sensory and motor blocks in studied patients.

Surgery was completed uneventfully in all studied patients; 22 patients (44%) in either group had intraoperative sedation with target-controlled propofol infusion ($P = 0.92$). Fentanyl supplementation during surgery was given to 18 (36%) patients in Group S and 20 (40%) patients in Group C ($P = 0.68$), with a median (range) dose of fentanyl of 100 μ g (50-200 μ g) and 100 μ g (100-200 μ g) in Groups S and C, respectively ($P = 0.43$). The median (range) duration of surgical procedure was similar in the 2 groups (50 [30-120] min and 40 [30-140] min in Groups S and C, respectively; $P = 0.895$).

In 3 patients, 2 in Group S (4%) and 1 in Group C (2%) ($P = 0.98$), the postoperative pain relief was not adequate despite the use of the maximum allowed

Table 3. Proportion of Patients with Loss of Pinprick Sensation in the Common Peroneal and Tibial Nerve Distributions, and Persistence of Motor Block in the Operated Foot at 24 and 48 h

Sensory and motor blocks at 24 h	Group S (n = 47)	Group C (n = 48)	P-value
Loss of pinprick sensation			
Tibial nerve	32 (68%)	33 (69%)	0.94
Common peroneal nerve	29 (61%)	35 (72%)	0.27
Inability to move the ankle joint	2 (4%)	1 (2%)	0.61
Sensory and motor blocks at 48 h ^a	Group S (n = 32)	Group C (n = 34)	P-value
Loss of pinprick sensation			
Tibial nerve	25 (78%)	29 (71%)	0.99
Common peroneal nerve	23 (71%)	28 (75%)	0.78
Inability to move the ankle joint	0 (0%)	0 (0%)	0.99

Data are presented as number (%).

^a The 48 h observation included only 34 and 32 patients in Groups C and S, respectively, because the other patients were discharged home before completing the 48 h observation period.

Table 4. Consumption of Local Anesthetic During the Study Period

	Group S (n = 47)	Group C (n = 48)	P-value
First postoperative day	122 (72–191)	148 (72–220)	0.038
Second postoperative day ^a	162 (80–308)	194 (97–305)	0.046
Total consumption ^a	239 (175–519)	322 (184–508)	0.002

Data are presented as median (range).

^a The 48 h observation included only 34 and 32 patients in Groups C and S, respectively, because the other patients were discharged home before completing the 48 h observation period.

volume of local anesthetic and rescue opioid analgesia. After a supplementary 10 mL bolus of 1% mepivacaine confirmed that the catheter was not in the correct position, it was removed (secondary block failure), and IV opioids PCA were given for pain management. Fifteen (31%) patients in Group S and 14 (29%) patients in Group C ($P = 0.82$) did not complete the 48-h data collection because they were discharged from the hospital before completing the whole observation period; data from these patients were recorded until hospital discharge and included into the 24-h observation time.

No difference in the evolution of sensory and motor block (Table 3) and quality of pain relief at rest and during motion (Fig. 1) was reported throughout the study period between the groups. Table 4 shows the volumes of local anesthetic consumed throughout the study in the two groups. At both 24 and 48 h, patients of Group S required significantly smaller volumes of 0.2% ropivacaine as compared with patients of Group C ($P = 0.002$).

Rescue opioid analgesia during the study period was required by 12 (25%) patients in Group S and 28 (58%) patients in Group C ($P = 0.002$), with a mean (95% confidence intervals [CI]) number of requests of rescue analgesic medication of 1.0 (95% CI, 0.8–1.3) in Group S and 1.5 (95% CI, 1.2–1.8) in Group C ($P = 0.05$).

Median (range) patient satisfaction score was 9 cm (6–10 cm) in Group S and 8 cm (2–10 cm) in Group C

($P = 0.10$). No neurological complications at 1 wk and no difference in the incidence of side effects, such as postoperative nausea and vomiting (1 [2%] and 2 [4%] patients in Groups S and C, respectively; $P = 0.98$), were observed.

Discussion

This prospective, randomized, blind investigation demonstrated that the use of a stimulating catheter results in a shorter onset time of sensory and motor blocks, less local anesthetic consumption during the first 48 h after surgery, and less need for postoperative rescue opioid analgesics.

Although they are usually considered as minor procedures, and often performed on an outpatient basis, surgery to the foot induces severe and long-lasting postoperative pain, which is difficult to control with standard oral analgesic medications (14). Peripheral nerve blocks have been proposed to treat such pain. The single-dose technique does not prolong pain relief for more than 10–15 hours, even when a long-acting local anesthetic such as bupivacaine, ropivacaine, or levobupivacaine is used (15,16). For this reason, many authors preferred to use continuous nerve blocks for these procedures, including home infusions (4,11,17–19).

Perineural catheters are usually inserted using a “blind” technique, i.e., by threading a plastic catheter

for 2–4 cm beyond the tip of an insulated, stimulating introducer (11). This technique has been reported to be very effective when the practitioner is properly trained (9,11); however, in less experienced hands, it is associated with frequent failure. Indeed, during blind insertion, the physician has no direct feedback of the catheter position. Although injection of a radioopaque solution has been used to assess catheter position, there is only a weak relationship between the radiological image of the perineural catheter's position and its clinical effectiveness (5). A stimulating catheter gives the possibility of confirming the perineural catheter positioning before initiating continuous infusion by using a stimulating catheter. Theoretically, this may improve the quality of nerve block and thus postoperative analgesia (6–8). After initial promising results (20,21), the use of stimulating catheters has grown over the last few years. Nonetheless, they are more expensive than regular sets⁶, and there is no clear evidence of their advantages in routine clinical practice. Pham-Dang et al. (6) evaluated the use of a stimulating catheter for both upper and lower extremity surgery in 130 patients. In their study, they elicited, with the stimulating introducer, an adequate muscular twitch with a current intensity ≤ 0.5 mA. After catheter advancement for 3–5 cm beyond the introducer tip, the nerve stimulator was connected to the stimulating catheter to verify its adequate perineural position. The authors reported an insertion failure as frequent as 37%. However, repetition of the maneuver in those cases with inadequate catheter placement resulted in a global 98% success rate. Salinas et al. (8) compared the success rate and quality of continuous femoral nerve block in 20 volunteers using a conventional nonstimulating perineural catheter on one limb and a stimulating catheter on the other limb. They reported a significant increase in success rate from 85% with the nonstimulating catheter to 100% with the stimulating one. Moreover, the overall tolerance to transcutaneous electrical stimulation and depth of motor block were significantly better in the stimulating catheter group. Conversely, when comparing the efficiency of continuous femoral nerve block after total knee arthroplasty, Morin et al. (10) reported similar quality of intraoperative nerve block, postoperative IV opioid consumption, and pain relief at rest and during movement when the block was performed with a stimulating or a nonstimulating catheter.

The present findings on onset time of sensory and motor blocks, local anesthetic consumption during the first 48 h after surgery, and need for postoperative rescue pain medication are in agreement with those reported by Salinas et al. (8) in their volunteers study.

Secondary block failure reported in the present investigation ranged between 2% and 4%. Such incidence is much less than the 15% failure rate reported by Salinas et al. (8) and the 37% first insertion failure

reported by Pham-Dang et al. (6); however, it is similar to that reported in different studies on continuous sciatic nerve block performed with a nonstimulating catheter for different foot procedures (4,17,19). Hence, the use of a stimulating catheter does not seem to reduce the secondary block failure rate for the popliteal approach to the sciatic nerve.

In the present investigation, we did not measure the current required to elicit a motor response through the catheter placed with the blind technique to see if this was different than that obtained when inserting the catheter while stimulating. This can be considered a pitfall of the study; however, Morin et al. (10) and Salinas et al. (8) reported that a higher stimulating current was required to obtain the adequate muscular twitch when stimulating through a catheter placed with the blind technique (range, 0.3–5 mA) as compared with those inserted with the stimulating technique (range, 0.1–0.3 mA). This observation may explain the smaller postoperative local anesthetic consumption observed in our study with the stimulating catheter technique.

In conclusion, results of this prospective, randomized, blind study show that the use of a stimulating catheter during continuous sciatic nerve block for elective foot surgery results in a shorter onset time of sensory and motor blocks, a smaller consumption of local anesthetic solution after surgery, and less need for rescue pain medication to maintain adequate pain relief.

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