# Ultrasound-Guided Popliteal Block Distal to Sciatic Nerve Bifurcation Shortens Onset Time

## *A Prospective Randomized Double-Blind Study*

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**Background and Objectives:** Popliteal sciatic nerve block (SNB) in combination with saphenous nerve block provides anesthesia and analgesia for foot and ankle surgeries. Landmark-based and image-guided techniques, to date, aim at blocking the sciatic nerve proximal to its bifurcation. Sciatic nerve block is usually associated with a long onset time (30–60 mins). We hypothesized that SNB distal to its bifurcation (blocking its 2 main branches tibial and common peroneal nerves separately) is associated with a shorter onset time than blockade proximal to its bifurcation.

**Methods:** Fifty patients scheduled for major elective foot or ankle surgery were randomly allocated to receive ultrasound-guided SNB 5 cm proximal to (group P) or 3 cm distal to (group D) its bifurcation in the popliteal fossa. Thirty milliliters of a standardized local anesthetic solution of equal volumes of 2% lidocaine and 0.5% bupivacaine with 1:200,000 epinephrine was used. Sensory and motor assessments were performed every 5 mins by a blinded observer until complete sensory and motor blockade developed in both tibial and common peroneal nerve territories.

**Results:** All patients in both groups developed a complete block. Patients in group D presented a 30% shorter onset of both sensory (21.4 [SD, 9.9] vs 31.4 [SD, 13.9] mins) ($P = 0.005$) and motor block (21.5 [SD, 11.3] vs 32.4 [SD, 14.9] mins) ($P = 0.006$) than patients in group P. Procedure time, procedure-related discomfort, and patient satisfaction were similar in both groups.

**Conclusions:** Our data suggest that popliteal SNB distal to the bifurcation has a shorter onset time than SNB proximal to its bifurcation, and therefore, it may be a good option when a fast onset for a surgical block is required.

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Popliteal sciatic nerve block (SNB) in combination with saphenous nerve block provides excellent anesthesia and analgesia for surgeries in the foot and ankle.[1–3] Both landmark-based and image-guided techniques aim at blocking the sciatic nerve close to the apex of the popliteal fossa, proximal to its bifurcation into the tibial and common peroneal nerves.[4–6] However, a prolonged onset time for complete blockade of up to 30–60 mins is common and may be a disadvantage to the use of popliteal SNB as an anesthetic option when time is limited.[4] This delayed onset has been attributed to the large size of the sciatic nerve.[7,8]

We hypothesize that selectively blocking both tibial and common peroneal nerves distal to the bifurcation may result in a faster block onset compared with blockade of the sciatic nerve proximal to its bifurcation.

## MATERIALS AND METHODS

After obtaining University Health Network Research Ethics Board approval and patient's written informed consent, 62 subjects were randomly allocated to 1 of 2 study groups. Patients in group P received ultrasound-guided SNB 5 cm proximal to the bifurcation. Patients in group D received ultrasound-guided block of the tibial and common peroneal nerves 3 cm distal to the bifurcation. Inclusion criteria were American Society of Anesthesiologists physical status I–III, 18 to 85 years of age, 50 to 150 kg, and greater than 150 cm in height, and scheduled for elective major ankle or foot surgery. Exclusion criteria were allergy to local anesthetics, coagulopathy, malignancy or infection in the popliteal area, significant peripheral neuropathy or neurologic disorder of the lower extremity or any other contraindication to SNB, pregnancy, history of alcohol or drug dependency/abuse, and a history of significant cognitive or psychiatric disorder that may affect patient assessment.

Randomization was performed on the day of surgery according to a computer-generated list of random numbers. Randomization information was kept in sealed individual envelopes, which were opened by the anesthesiologist immediately before block performance. Patients and study personnel performing postblock assessments were blinded to group allocation. Anesthesiology staff or fellows (who had performed at least 20 prior ultrasound-guided popliteal blocks) performed the blocks preoperatively in a dedicated regional anesthesia room.

Peripheral intravenous access was established, and an infusion of normal saline was started at a maintenance rate. Routine electrocardiogram, noninvasive blood pressure, and pulse oximeter monitoring were applied, and baseline readings were obtained. Midazolam 1 to 4 mg was intravenously administered for anxiolysis as necessary. Patients were positioned prone. The area over the popliteal fossa was sterilized with 2% chlorhexidine in 70% isopropyl alcohol. The posterior knee crease was marked with a sterile marker. A Philips HD11XE ultrasound unit (Philips, Bothell, Wash) or SonoSite MTurbo ultrasound unit (SonoSite Inc, Bothell, Wash) and a high-frequency (6–12 MHz) linear array transducer were used. The ultrasound transducer was prepared in a sterile manner. The sciatic nerve was identified in the midthigh (in a transverse plane or short-axis view) between the semitendinous and semimembranous

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muscles medially and the biceps femoris laterally. The sciatic nerve was then followed distally along its course, until the bifurcation into its 2 distal branches (tibial nerve and common peroneal nerve) was identified. The tibial nerve is usually the larger of the two and follows a longitudinal course along the long axis of the distal thigh, in close relationship with the popliteal vessels. The common peroneal nerve is usually slightly smaller than the tibial nerve, and it moves laterally after branching out. The site of bifurcation was marked on the skin, and its distance from the popliteal crease was recorded.

All blocks were performed using an 80-mm, 22-gauge Pajunk needle (Pajunk, Geisingen, Germany), with a needle-in-plane approach after skin and subcutaneous infiltration with 1 to 2 mL of 1% lidocaine. Thirty milliliters of a standardized local anesthetic solution consisting of equal volumes of 2% lidocaine and 0.5% bupivacaine with 1:200,000 epinephrine was used. For patients in group P, 30 mL of this solution was injected around the sciatic nerve 5 cm proximal to its bifurcation in a circumferential manner (Fig. 1). For patients in group D, 15 mL of the same solution was injected around the tibial nerve and 15 mL around the common peroneal nerve, 3 cm distally to the site of bifurcation, in a circumferential manner (Fig. 2). All injections were performed just outside the epineurium.

A saphenous nerve block was performed if considered necessary for the particular surgical procedure, after assessment of SNB progression was complete.

The primary outcome was the time to achieve a complete sensory block in the distribution of both terminal branches of the sciatic nerve. An independent blinded observer, not present during block performance, assessed block progression every 5 mins for 60 mins or until the start of surgery. Sensory function was assessed by sensation to pinprick with a 23-gauge needle in the following locations: (*a*) tibial nerve: plantar surface of the foot and (*b*) peroneal nerve: dorsolateral aspect of the foot. Sensation to pinprick in each nerve territory was graded as 0 = complete loss of sensation to pinprick, 1 = decreased sensation to pinprick, or 2 = normal pinprick sensation. Motor function was assessed as follows: (*a*) tibial nerve: plantar flexion of the foot and (*b*) peroneal nerve: dorsiflexion of the foot. Motor function was graded as 0 = no movement, 1 = movement present but weaker than baseline, or 2 = normal movement and power. A composite sensory-motor score was obtained for each patient at each assessment time point by adding both sensory and motor scores in each nerve territory. A score of 8 represents full sensory and motor baseline function. A score of 0 represents complete loss of sensory and motor functions in the distribution of both target nerves.


**FIGURE 1.** Ultrasound scan of the sciatic nerve in the popliteal fossa, proximal to the bifurcation.

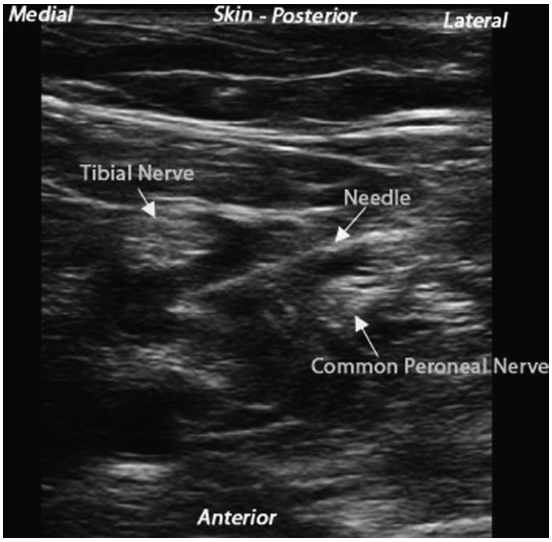


**FIGURE 2.** Ultrasound scan of the tibial and common peroneal nerves in the popliteal fossa, 3 cm distal to sciatic nerve bifurcation. Note the needle position between the 2 nerves and the local anesthetic spread.

Secondary outcomes included block procedure time (defined as the time elapsed from ultrasound probe preparation until completion of local anesthetic injection); postoperative pain using an 11-point verbal rating score, where 0 = no pain, 10 = excruciating pain recorded immediately after and 2 hrs after surgery; patient satisfaction; and block-related complications. Patients satisfaction was assessed using a 0- to 10-point verbal rating scale, where 0 = very unsatisfied and 10 = very satisfied with the block procedure. Patients were interviewed over the phone 24 hrs and 7 days after surgery to document block regression time (as duration of analgesic effect), overall satisfaction with analgesia, and block-related complications.

## Sample Size Calculation and Statistical Analysis

A previous study from our institution using the same local anesthetic solution and volume to block the sciatic nerve proximal to its bifurcation suggests that the mean time for a complete sensory block is 30 mins, with an SD of 15 mins.[4] We hypothesized that by blocking both terminal branches of the sciatic nerve separately, distal to its bifurcation, block onset time may be shortened. To detect a decrease from 30 to 20 mins, with an $\alpha = 0.05$ and a $\beta = 0.1$ (power of 90%), we estimated a minimum required sample size of 24 patients per group.

The primary outcome measure (development of complete sensory block) was expressed as mean (SD) and compared using Student *t* test. Demographics and secondary outcome measures were compared using Student *t* test for comparison of mean values or Mann-Whitney *U* test where appropriate. SPSS for

**TABLE 1.** Demographics and Block Characteristics

| | Proximal Group (n = 25) | Distal Group (n = 25) | |
|---|---|---|---|
| | Mean (SD) | Mean (SD) | *P* |
| Age, y | 43 (12) | 45 (13) | 0.46 |
| Height, cm | 172 (10.0) | 171 (14) | 0.90 |
| Weight, kg | 87 (24) | 87 (14) | 0.94 |
| BMI, kg/m$^2$ | 29 (7) | 31 (11) | 0.61 |
| Sex, male-female ratio | 1.7:1 | 1.7:1 | 0.52 |
| Midazolam dose, mg | 2.4 (0.8) | 2.3 (0.7) | 0.90 |
| Procedure time, min | 9 (3) | 12 (9) | 0.08 |
| Distance of sciatic nerve bifurcation to popliteal crease, cm | 7.7 (2.8) | 7.8 (3.5) | 0.87 |
| Distance from greater trochanter to lateral condyle, cm | 40 (3) | 40 (3) | 0.60 |
| | Median (IQR) | Median (IQR) | *P* |
| Procedure-related pain (VAS: 0–10) | 3 (1.5–5) | 2 (1–4) | 0.36 |
| No. skin entry sites | 1 (1–1) | 1 (1–2) | 0.05 |

IQR indicates interquartile range; VAS, visual analog scale.

Windows, version 15.0 (SPSS Inc, Chicago, Ill), was used for the analysis.

## RESULTS

Sixty-two patients consented to participate in the study and were randomized. Fifty patients completed study assessments and were included in the final analysis. Eleven patients were excluded after randomization because of insufficient time available to perform study assessment, because of an earlier-than-expected surgical start time. One patient was excluded because of inability to identify the site of sciatic nerve bifurcation. Patient demographics and block characteristics are summarized in Table 1. Sciatic nerve bifurcation was located at a mean distance of 7.7 (SD, 2.8) cm and 7.8 (SD, 3.5) cm from the popliteal crease in the proximal and distal groups, respectively. Midazolam dose and block procedure time did not differ between groups. In group P, all blocks were performed with a single needle insertion point. In group D, a second needle insertion through the skin was required in 10 patients to reach both tibial and common peroneal nerves properly. All patients developed a complete surgical block in both groups.

Sensory block developed earlier in group D (21.4 [SD, 9.9] vs 31.4 [SD, 13.9] mins) ($P$ = 0.005). Motor block also developed earlier in group D (Table 2; Fig. 3).

There were no differences between groups in postoperative pain, block duration, or patient satisfaction with postoperative analgesia. No vascular punctures were reported in either group. One patient in group P and 3 patients in group D reported persistent numbness in the sciatic nerve distribution 24 hrs after surgery, but this had resolved by 7 days.

## DISCUSSION

The results of our present study confirm our hypothesis that a faster block onset may be achieved by blocking the tibial and common peroneal nerves separately distally to sciatic nerve bifurcation, with a relative reduction in onset time of approximately 30%.

**TABLE 2.** Results

| | Proximal Group (n = 25) | Distal Group (n = 25) | |
|---|---|---|---|
| Assessment | Mean (SD) | Mean (SD) | *P* |
| Time to complete sensory anesthesia, min | 31 (14) | 21 (10) | 0.005 |
| Time to complete motor blockade, min | 32 (15) | 22 (11) | 0.006 |
| Time to complete motor and sensory blockade, min | 34 (14) | 24 (11) | 0.011 |
| Surgical time, min | 76 (32) | 96 (62) | 0.08 |
| Duration of analgesia, hrs | 14 (10) | 14 (13) | 0.99 |
| | Median (IQR) | Median (IQR) | *P* |
| Pain in postoperative unit (VAS: 0–10) | 0 (0–0) | 0 (0–0) | 0.90 |
| Patient satisfaction with analgesia on POD 7 | 10 (8–10) | 10 (8.75–10) | 0.79 |
| Vascular punctures | 0 | 0 | |
| Persistent numbness at 24 hrs | 1 | 3 | |
| Persistent weakness at 24 hrs | 0 | 0 | |

IQR indicates interquartile range; POD, postoperative day; VAS, visual analog scale.

 

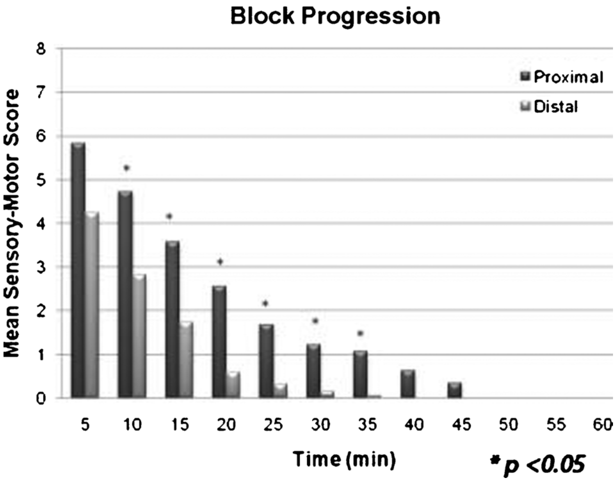


**FIGURE 3.** Composite sensory-motor score at each time interval. A score of 8 indicates complete motor and sensory function. A score of 0 indicates complete motor and sensory block in the tibial and common peroneal nerve territories.

The tibial and common peroneal components of the sciatic nerve are 2 distinct functional entities surrounded by a single epineurial sheath within the sciatic nerve, starting proximally in the nerve, even possibly within the pelvis.[9] The site of apparent physical separation of both nerves occurs usually close to the apex of the popliteal fossa, but is highly variable among individuals. Therefore, when nerve stimulator guidance is used as a sole nerve-finding tool for popliteal block, some authors suggest that a double-injection technique seeking a dual motor response of both the tibial and common peroneal nerves may be superior to a single-response technique, particularly if the block is performed distally within the popliteal fossa. In the absence of image guidance, it is not possible to know with certainty if the selected needle insertion site lies proximally or distally to sciatic nerve bifurcation. Therefore, a double motor response would ensure that both components of the nerve are being blocked.[10,11] More recently, however, ultrasound guidance is being increasingly used to guide popliteal SNB,[12–14] with some studies suggesting higher success rates than nerve stimulator techniques.[4,5] One of the possible advantages of ultrasound guidance is that it allows precise identification of the site of bifurcation ensuring, once again, blockade of the entire nerve. Most authors of ultrasound-guided studies, to date, have targeted the sciatic nerve proximal to its bifurcation. In the present study, the selection of injection sites for both groups (5 cm proximal and 3 cm distal to sciatic nerve bifurcation) is rather arbitrary and is an attempt to standardize the site of blockade with respect to the site of bifurcation, which is more anatomically relevant than external landmarks and allows us to properly address the study question.

However, irrespective of the nerve localization technique used, successful SNB is often associated with a slow onset time, of usually 30 to 60 mins. The reason for this prolonged onset has not been conclusively determined, but it has been speculated that it may be related to the large size of the sciatic nerve.[7,8]

Many factors can potentially affect block onset time for any given peripheral nerve block. Most physiologic studies in this area have been performed on either single nerve fibers or isolated whole nerves exposed to a local anesthetic "bath." First, it has been established that local anesthetic solutions with higher concentration, higher lipid solubility, and higher $pK_a$ usually result in faster block onsets.[15] Second, some in vitro studies on frog sciatic nerves suggest that the degree of nerve blockade is also directly related to the length of nerve exposed.[16] On single-nerve-fiber recordings, there is a minimum critical exposure length (equivalent to at least 3 consecutive nodes of Ranvier or 3–6 mm) required to block conduction.[16] Similarly, the combined action potential for the entire sciatic nerve decreases as the length of exposure to local anesthetic solution increases up to 3 to 4 cm along the longitudinal axis of the nerve.[16] This concept of "critical length of exposure" may be an important factor that influences onset and block intensity at very low local anesthetic volumes, but it should not be a limiting factor at the volumes and concentrations used in our study. Third, block onset is dependent on the time it takes for the local anesthetic deposited outside the nerve's epineurium to physically diffuse toward the nerve center. The perineural sheath presents a major diffusion barrier to local anesthetics reaching the nerve axons. Classical studies using radioactive local anesthetic solutions have determined that only 5% of the local anesthetic injected during SNB actually crosses the epineurium to reach the neural fibers.[17] It is also known that axons that reside in the outer layers of a nerve are anesthetized well before core fibers.[18] The fact that the sciatic nerve is the largest nerve in the human body and has a well-defined thick epineurium may explain this prolonged onset time. Some previous studies reporting a faster-than-usual onset time for SNB suggested a possible subepineurial needle placement.[19]

In our study, a standardized local anesthetic solution, with the same local anesthetic type, concentration, acidity, and volume, was used in both groups. The total volume administered (30 mL in group P and 15 mL for each nerve in group D) would certainly ensure longitudinal spread beyond the recommended "critical exposure lengths" in both groups. It is possible then that, in our study, the main factor explaining the difference in onset is nerve diameter at the site of blockade, with a faster onset achieved by blocking 2 smaller nerves (tibial and common peroneal) distal to sciatic nerve bifurcation, rather than a larger nerve mass, encased by a single epineurium proximal to the bifurcation. If we assume that the additive cross-sectional area of the 2 distal nerves is approximately the same as the cross-sectional area of the sciatic nerve immediately before its bifurcation, then the total additive circumferential surface area exposed to the local anesthetic also remains unchanged. The minimum distance to the core fibers of each nerve, however, is significantly reduced, and this may explain a faster diffusion time toward the core fibers (Fig. 4).

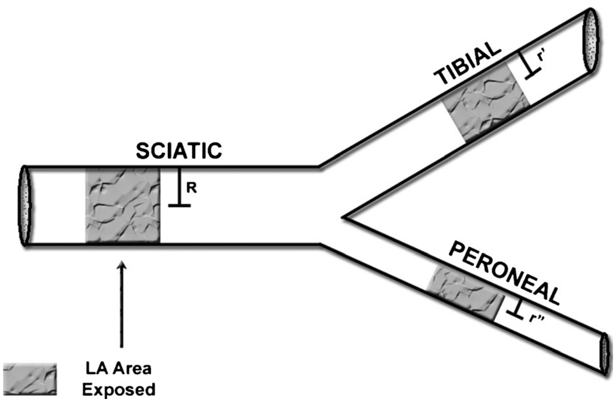


**FIGURE 4.** Schematic representation of sciatic nerve bifurcation. R, r′, and r″ represent the radii of sciatic nerve and tibial and common peroneal nerves respectively. Note that both r′ and r″ are less than R.

The results of this study are fully applicable only to image-guided popliteal blocks because it is only with image guidance that the site of nerve bifurcation can be conclusively established on a given patient. One possible limitation to this distal blockade technique is that sciatic nerve bifurcation may not be easily recognizable under ultrasound on every patient. One patient in our study (of a total of 62 who consented) was excluded because of the inability to locate the precise site of bifurcation on this patient. This site was easily recognizable on the remaining 61 patients.

All patients in group P had 30 mL of the local anesthetic solution deposited in 1 single area around the sciatic nerve, 5 cm proximal to its bifurcation, and this was achieved with a single skin puncture. All patients in group D had 15 mL of the same local anesthetic solution deposited around each tibial and common peroneal nerves (for a total of 30 mL). This was achieved with a single needle entry site through the skin in 60% of patients in group D, but required a second skin puncture site in 40% of patients in group D, to ensure similar local anesthetic spread in all patients in the group. This was well tolerated and did not result in either increased procedure time or greater procedure-related discomfort in this patient group. (Table 2) It should be noted that this second injection is only a minor technical distinction and should not be confused with the concepts of "single" versus "double" injection technique from the nerve stimulator literature.

## CONCLUSIONS

Popliteal fossa block distal to sciatic nerve bifurcation decreases onset time by approximately 30% as compared with blockade proximal to sciatic nerve bifurcation and may be a good option when a fast onset of surgical block is required.

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