Ultrasound guided injection inside the common sheath of the sciatic nerve at division level has a higher success rate than an injection outside the sheath

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Abstract
Background and objective: The recommendations for the level of injection and ideal placement of the needle tip required for successful ultrasound-guided sciatic popliteal block vary among authors. A hypothesis was made that, when the local anesthetic is injected at the division of the sciatic nerve within the common connective tissue sheath, the block has a higher success rate than an injection outside the sheath.
Methods: Thirty-four patients scheduled for hallux valgus repair surgery were randomized to receive either a sub-sheath block (n = 16) or a peri-sheath block (n = 18) at the level of the division of the sciatic nerve at the popliteal fossa. For the sub-sheath block, the needle was advanced out of plane until the tip was positioned between the tibial and peroneal nerves, and local anesthetic was then injected without moving the needle. For the peri-sheath block, the needle was advanced out of plane both sides of the sciatic nerve, to surround the sheath. Mepivacaine 1.5% and levobupivacaine 0.5% 30 mL were used in both groups. The progression of motor and sensory block was assessed at 5 min intervals. Duration of block was recorded.
Results: Adequate surgical block was achieved in all patients in the subsheath group (100%) compared to 12 patients (67%) in the peri-sheath group at 30 min. Sensory block was achieved faster in the subsheath than peri-sheath (9.1 ± 7.4 min vs. 19.0 ± 4.0; p < .001).
Conclusions: Our study suggests that for successful sciatic popliteal block in less than 30 min, local anesthetic should be injected within the sheath.

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Background

Ultrasound guided sciatic popliteal block is commonly used for surgical anesthesia and analgesia of the foot and ankle. Traditional teaching suggests that injection of local anesthetic proximal to the division of the sciatic nerve results in more consistent block of both the tibial nerve (TN) and the common peroneal nerve (CPN) divisions of the sciatic nerve. Nonetheless, the success rate of popliteal blockade for surgical anesthesia varies widely, possibly reflecting differences in technique and/or anatomical placement of the local anesthetic (89% to 100%). A recent debate over what constitutes intraneural versus perineural injection in sciatic popliteal blockade has fueled the controversy over whether the anesthetic should be injected outside or inside the common connective tissue sheath enveloping both divisions of the sciatic nerve.

Several recent studies addressed the effects of site of local anesthetic injection (proximal, distal, or at the level of division) on the success rate and speed of onset of the popliteal block. The spread of local anesthetic inside the common connective tissue sheath (CCTS) enveloping the sciatic nerve may confer faster and more dense block without evidence of nerve injury. This connective tissue is readily distinguishable during ultrasound imaging and is anatomically distinct from the epineurium of the TN and CPN. Within the context of sciatic popliteal blockade, this sheath may provide a useful conduit to distribute local anesthetic along the sciatic nerve and its two divisions.

Using ultrasound guidance, we compared block injection inside the CCTS between the TN and CPN to injection outside the CCTS at the same level, using block success rate (surgical anesthesia at 30 min) as the primary outcome. Secondary outcomes were time to block onset, and duration of postoperative analgesia. We hypothesized that an injection within the CCTS results in a higher success rate than an injection outside the CCTS when local anesthetic is injected at the division of the sciatic nerve.

Methods

This study was approved by the Institutional Review Board (2012/7863). Written informed consent was obtained from 100 patients (ASA I–II) scheduled for ambulatory hallux valgus repair (bunion surgery) under popliteal block. Exclusion criteria were known history of peripheral neuropathy, obesity (>35 kg/m²), and inability to obtain clear ultrasound images of the sciatic nerve, TN and CPN during the preblock examination of the popliteal fossa.

Patients were randomly assigned to two groups, S-CCTS and P-CCTS, using sequentially numbered, opaque, sealed envelopes. After establishing peripheral venous access, standard noninvasive monitoring, and premedication with 1–2 mg of iv midazolam, the patients were positioned prone with the foot to be blocked elevated 10 cm on a cushion. The sciatic nerve was imaged in the short axis with a 6–13 MHz linear transducer (L38, Turbo, Sonosite, Bothell, USA) in the popliteal fossa to obtain the best view of the sciatic nerve at the level of the bifurcation. All blocks were performed by physician experts in ultrasound-guided regional anesthesia. The target injection level was where the TN and CPN were seen separated by 1–3 mm. The area of the nerve was measured by outlining the sciatic nerve, during ultrasound imaging at the level of the block before and after injection. The area of the nerve was defined for the purpose of this study by including the CCTS. After skin infiltration with 1 ml of 2% lidocaine, a 50 mm, 22 gauge, 15° bevel stimulating...
needle (Stimuplex D 50 B. Braun Melsungen AG, Germany) containing equal volumes of mepivacaine 1.5% and levobupivacaine 0.5% was introduced in an out-of-plane approach. The same mixture of local anesthetics was used in both groups.

**Injection within the common connective tissue sheath (S-CCTS)**

For injection within the CCTS (i.e., sub-common connective tissue sheath), the needle was advanced out-of-plane inside the CCTS between the TN and CPN. Upon penetrating the CCTS, location of the needle tip was confirmed by observing the spread of 1 ml of dextrose 5% in water separating the TN and CPN (Fig. 1). The injection was completed with 30 ml of local anesthetic. Successful S-CCTS injection was defined as a post-injection increase of ≥30% in nerve area and proximal-distal diffusion of local anesthetic ≥3 cm.11

**Injection outside the common connective tissue sheath (P-CCTS)**

For injection outside the CCTS (i.e., the peri-common connective tissue sheath), two aliquots of local anesthetic were injected on opposite sides of the sciatic nerve (Fig. 1). The needle was advanced until the tip traversed the epimyisum of the biceps femoris muscle and was positioned just outside the CCTS. The position of the needle in the immediate vicinity of the CCTS was confirmed with an injection of 1 ml of DW5. Upon successful needle placement, two aliquots of local anesthetic were injected, 15 ml of local anesthetic was injected on the lateral aspect of the CCTS, followed by an injection of 15 ml on the medial aspect of the CCTS. Successful injection was defined as a circular spread of local anesthetic around the CCTS of the sciatic nerve (Fig. 1). Any spread of local anesthetic within the CCTS (defined as separation of TN and CPN resulting in an increase of cross sectional area) was considered as accidental intra-CCTS injection. Patients with intra-CCTS injection in this group were excluded from the analyses.

**Needle guidance and ultrasound assessment**

For both approaches, out-of-plane ultrasound guidance was used. The block needles were connected to a nerve stimulator (1.0 mA, 2 Hz; 0.1 ms; Stimuplex NHS B. Braun Melsungen AG, Germany). Injection was stopped if a motor response was present at <0.3 mA, or high resistance to injection was encountered, which prompted slight needle withdrawal. Before and after injection, nerve area and diffusion of local anesthetic along the nerve and its divisions were measured.

The evolution of motor and sensory block of the TN and CPN was assessed by a blinded observer every 5 min for 30 min or until the block was complete (whichever came first). Sensory block was assessed by pinprick and graded on a 4-point scale: (3) normal sensation, (2) decreased sensation, (1) tactile but no pain sensation, (0) no sensation at all. The tests were conducted in the distribution area of the tibial
nerve (sole of foot), superficial peroneal nerve (dorsal foot), deep peroneal nerve (interdigital skin between the 1st and 2nd toe), and sural nerve (lateral aspect of the foot). Motor block was graded on a 4-point scale: (3) full strength, (2) weak response against resistance, (1) paresis, (0) paralysis. Successful anesthesia was defined as a sensory block score 1 or 0 and ability to perform the surgical procedure without additional local anesthetic infiltration and/or conversion to general anesthesia. A tourniquet was used at the level of the ankle to provide a bloodless field. Intraoperative management consisted of conscious sedation with midazolam in 1 mg increments.

To evaluate the duration of postoperative analgesia after discharge, patients were instructed to record their VAS scores at specific time points (at 6, 12, 20 and 24 h after the block). A standard regimen of oral analgesics included acetaminophen 1 g, and dextropropoxyphene 25 mg, both every 8 h, and tramadol 50 mg as rescue medication. Time of first pain and the incidence and intensity of breakthrough pain during the night were recorded. Incidence of sensory-motor (neurologic) deficit was assessed one and four weeks after surgery by the participating surgeon.

### Statistical analysis

The primary outcome was the rate of adequate surgical anesthesia at 30 min. Based on our clinical experience, the proportion of patients with successful surgical block at 30 min after S-CCTS is nearly 99%. We predicted successful surgical anesthesia in 85% of blocks after P-CCTS injection. The sample size to detect this difference in proportions with an α error of 0.05 and β error of 0.2 was estimated to be 46 subjects per group. Assuming a dropout of approximately 10%, 50 patients were included in each group.

Difference in proportions of patients with block failure at 30 min was tested by chi-square test. Kaplan–Meier curves were used to illustrate proportions of patients with complete block at 5, 10, 15, 20, 25 and 30 min. Chi-square and Fisher’s exact tests were used to test differences in proportions. Student’s t test or Mann–Whitney U was used to compare continuous or ordinal variables. Statistical significance was considered at the 0.05 level.

### Results

After enrolling the first 34 subjects (n = 16 S-CCTS group; n = 18 P-CCTS group), an interim analysis was conducted to evaluate the unusually high failure of the sciatic popliteal block to provide surgical anesthesia. The unexpectedly high failure rate was identified in the P-CCTS group (33% in contrast to 0% in the S-CCTS group), and the study was stopped. All enrolled patients were included in the analysis. There were no significant differences in demographic characteristics, ASA physical status or type of surgery between the groups (Table 1).

Ultrasound criteria of sub-sheath injection, increase in nerve area and diffusion of local anesthetic proximally and distally, occurred in all patients in the S-CCTS group. Mean increase in the defined nerve area after S-CCTS injection was 1.5-fold (36–202%), and all injections demonstrated proximal-distal diffusion of local anesthetic >3 cm. In contrast, P-CCTS injections did not increase nerve area and did not result in proximal-distal diffusion >3 cm.

At 30 min, all S-CCTS blocks resulted in successful surgical anesthesia (sensory block grade 1 or 0) compared to 12 patients (67%) in the P-CCTS group (p = 0.003). The remaining six patients in the P-CCTS group required a rescue block for surgery. Moreover, all patients in the S-CCTS group had surgical block already at 15 min. Complete sensory and motor block (grade 0) was achieved in all patients in the S-CCTS at 30 min as compared to a single patient (6%) in the P-CCTS group (p < 0.001).

Onset time of sensory and motor block was faster in S-CCTS than in P-CCTS injections (Figs. 2 and 3). Mean time to achieve surgical block was shorter in the S-CCTS group (9 ± 3 min, 95% CI 8–10 min) compared to the P-CCTS group (19 ± 4 min, 95% CI 17–21 min; p < 0.0001).

Duration of postoperative analgesia was highly variable in both groups. There was no difference in duration of analgesia between the 16 patients in the S-CCTS group and the 12 patients in the P-CCTS group with successful blocks [21 ± 6 h (CI95%; 18–24 min) vs. 19 ± 6 h (CI95%; 16–22 min); p = 0.5]. The six patients in the P-CCTS with failed surgical anesthesia that required a rescue blocks to start the surgery (2 sciatic popliteal and 4 ankle blocks) were analyzed separately (Table 2). Likewise, there was no difference in the incidence of night-time pain or in severity of pain at the studied time intervals (Table 2).

Motor response was elicited in 10 (62%) patients in the S-CCTS group (0.61 ± 0.17 mA) and in 12 (66%) patients in the P-CCTS group (0.69 ± 0.14 mA). No patient complained of pain or paresthesias during the procedure. None of the injections were stopped due to high resistance to local anesthetic injection. Sub-sheath position of the needle tip between the TN and CPN was confirmed by hydrolocalization in all patients in the S-CCTS group at first attempt. Needle reposi- tion was required in four patients in the P-CCTS group after confirming initial sub-sheath spread of dextrose 5% in water.

None of the patients had residual sensory-motor deficit during the neurologic examination at 1 and 4 postoperative weeks. Likewise, no patient in either group reported symp- toms suggestive of neurologic injury at 24 h, or at 1 and 4 weeks after the blockade.

### Discussion

Our study suggests that an injection within the common sheath of the sciatic nerve (S-CCTS) is desirable for reliable surgical anesthesia in less than 30 min. These findings are in

<table>
<thead>
<tr>
<th>Table 1 Descriptive and anthropometric data.</th>
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<tbody>
<tr>
<td>S-CCTS (n = 16)</td>
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<tr>
<td>P-CCTS (n = 18)</td>
</tr>
<tr>
<td>Age (yrs)</td>
</tr>
<tr>
<td>58 ± 14</td>
</tr>
<tr>
<td>62 ± 12</td>
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<tr>
<td>Weight (kg)</td>
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<td>69 ± 13</td>
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<td>64 ± 10</td>
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<td>Height (cm)</td>
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<td>157 ± 8</td>
</tr>
<tr>
<td>Gender (M/F)</td>
</tr>
<tr>
<td>2/14</td>
</tr>
<tr>
<td>1/17</td>
</tr>
<tr>
<td>ASA I/II/III</td>
</tr>
<tr>
<td>64/10/2</td>
</tr>
<tr>
<td>4/13/1</td>
</tr>
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</table>

S-CCTS: sub-common connective tissue sheath; P-CCTS: peri-common connective tissue sheath data expressed as mean ± SD and number of patients.
agreement with the recommendations by Vloka et al. who reported that injection of local anesthetic inside the sheath is necessary in order to distribute the injectate around both divisions of the sciatic nerve. Several recent reports also suggest that injections within the CCTS are more reliable to accomplish successful sciatic popliteal block. For instance, Missair et al. reported a greater volume of local anesthetic in contact with the sciatic nerve when the injection was performed beneath the CCTS compared to a circumferential injection outside the CCTS just proximal to the division. Our study also documents that an injection of local anesthetic outside the CCTS results in a significantly higher failure rate, even when the block is performed at the same level of the sciatic nerve.

Ultrasound guided injection of local anesthetic inside the CCTS at the level of division between both branches of the sciatic nerve is readily identified as an increase in the defined nerve area and a circumferential spread of several cm proximally and distally, to the tibial and the common peroneal nerves. Sciatic popliteal block with such a pattern of spread of local anesthetic has faster onset than a more proximal block guided by nerve stimulation or a block

![Figure 2](image)

**Figure 2** Evolution of motor and sensory block in all nerve territories.

![Figure 3](image)

**Figure 3** Kaplan–Meier curves of the evolution of the sensory and motor block.
using two separate injections distal to the division of the sciatic nerve. However, we found that consistent sciatic popliteal block is not guaranteed even with documented spread of local anesthetic around the sciatic nerve after precise ultrasound-guided injection of local anesthetic outside the CCTS.

A recent review of the anatomy of the sciatic nerve focused on the nature and nomenclature of the connective tissue surrounding the sciatic nerve. Several different anatomical classifications have been proposed for connective tissue layers that varied from epimysium to epineurial sheath. Regardless of the exact contribution of the epimysium of hamstring muscle fasciae and epineural tissue of the sciatic nerve to the CCTS around the sciatic nerve, the CCTS is readily seen on ultrasound, as shown in Fig. 1. Our study demonstrates that for successful sciatic popliteal block in less than 30 min, local anesthetic should be injected within the CCTS. Recent in vitro data in animals suggest that the epineurium of the sciatic nerve provides some obstacle to the entry of the local anesthetic into the nerve.17

The failure rate in the P-CCTS group in our study was somewhat higher than that reported for more proximal approaches to sciatic popliteal block.4,5 In particular, Brull et al. reported a 94% success rate of sciatic popliteal block when multiple injections were performed proximal to the division to cover at least 75% of the nerve surface. In contrast, even when resulting in circumferential spread, single injections in that study resulted in a lower success rate. This suggests that a minimum length of diffusion in the longitudinal plane appears to be necessary for successful block.5 We can speculate that at the level of division, the loose fatty tissue that surrounded the nerve, in the patient population studied, did not facilitate the diffusion of LA inside and along the sciatic nerve. Tran et al. reported a success rate of 84% using a similar S-CCTS technique; the blocks being performed by trainees.9 Differences in success rate also depend on the definition and time of assessment.18 Of note, we did not find any difference in the duration of postoperative analgesia between the groups whose blocks were successful, regardless of site of local anesthetic injection (S-CCTS or P-CCTS). Moreover, and consistent with previous reports, block duration tended to be quite variable (12–24 h).1920

This study design has several limitations. First, the resolution of currently used US machines do not allow to see the exact position of the needle tip in relation to the limits of the nerve. During S-CCTS block, the needle may accidentally enter the epineurium of the TN or the CPN resulting in even faster block onset and an increased risk of potential nerve damage. On the other hand, repeated needle passes during the P-CCTS block may result in partial injection of LA inside the sheath which would have result in faster block onset or higher block success rate. Much care was taken to avoid both situations. Of note, we detected unintended sub-sheath injection of dextrose in 4 patients. Second, the planned sample size was not reached, which do not allow to draw conclusions on the secondary variables such as the duration of postoperative analgesia.

In conclusion, injection of local anesthetic into the CCTS at the level of division of the sciatic nerve results in significantly faster and more consistent block success rate for surgical anesthesia within 30 min than injection around the CCTS, which fails to achieve a surgical block in an unacceptable proportion of patients. Regardless of the method of injection, however, block duration among patients with successful blocks appears to be similar.

**Funding**

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**Conflict of interest**

The authors declare no conflicts of interest.

**References**


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**Table 2.** Evolution of postoperative analgesia.

<table>
<thead>
<tr>
<th>VAS Score postblock</th>
<th>S-CCTS (n = 16)</th>
<th>P-CCTS</th>
<th>p-Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Successful block (n = 12)</td>
<td>Rescue block (n = 6)</td>
<td></td>
</tr>
<tr>
<td>6 h</td>
<td>0 (0–2)</td>
<td>0 (0–2)</td>
<td>0 (0–2)</td>
</tr>
<tr>
<td>12 h</td>
<td>0 (0–2)</td>
<td>0 (0–4)</td>
<td>0 (0–3)</td>
</tr>
<tr>
<td>20 h</td>
<td>3 (0–6)</td>
<td>3 (0–6)</td>
<td>3 (0–8)</td>
</tr>
<tr>
<td>24 h</td>
<td>3 (0–7)</td>
<td>3 (0–8)</td>
<td>3 (0–0)</td>
</tr>
<tr>
<td>VAS Max</td>
<td>4 (0–8)</td>
<td>7 (0–8)</td>
<td>7 (0–8)</td>
</tr>
<tr>
<td>Night-time pain</td>
<td>7 (44%)</td>
<td>5 (42%)</td>
<td>3 (50%)</td>
</tr>
<tr>
<td>ANALGESIC BLOCK (h)</td>
<td>21 ± 6</td>
<td>19 ± 6</td>
<td>17 ± 7</td>
</tr>
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</table>

S-CCTS: sub-common connective tissue sheath; P-CCTS: peri-common connective tissue sheath data expressed as median (range).

* Between the S-CCTS group and the successful P-CCTS block.


