Original Article

# Quantitative assessment of ultrasound-guided sciatic nerve block – A comparison of a single-point versus two-point injection technique: A randomised controlled, double-blinded trial

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## ABSTRACT

**Background and Aims**: Sciatic nerve block at the popliteal level for lower limb procedures provides unpredictable success rates even with ultrasonographic (USG) guidance. This study aimed to compare USG-guided single-point versus two-point injection techniques**. Methods**: Sixty patients posted for foot surgeries under USG-guided sciatic nerve block were randomised into Group Single Point, receiving a single injection of 20 mL of 1.5% lignocaine with adrenaline just proximal to the sciatic nerve bifurcation, and Group Double Point, receiving two injections of 10 mL of 1.5% lignocaine with adrenaline, one at the point similar to the first group and a second injection 6 cm above the first point. Sensory blockade onset, time to complete sensory blockade, time to complete motor blockade, length of the nerve exposed and analgesia duration were evaluated. Statistical analysis was performed with Statistical Package for the Social Sciences (SPSS) statistics version 20 software. **Results**: Double-point injection technique showed a significantly faster time to complete motor blockade [14.46 (9.93) min], increased length of nerve exposed to local anaesthetic [23.23 (7.209) cm] and extended duration of analgesia [420.40 (99.34) min] compared to the single-point injection technique [20.89 (12.62) min, 18.78 (5.95) cm and 344.28 (125.97) min, respectively]. The onset of sensory blockade and the time to complete sensory blockade were comparable between the two groups. **Conclusion:** USG-guided popliteal sciatic nerve block with a double-point injection technique does not significantly shorten the time to complete the sensory block. However, the time to complete motor nerve block and duration of analgesia are prolonged significantly, which may be clinically beneficial for postoperative analgesia.

**Key words:** Analgesia, cutaneous current perception threshold, local anaesthetic, quantitative, sciatic nerve block, ultrasound-guided

## INTRODUCTION

Sciatic nerve block at the popliteal level is frequently employed to provide surgical anaesthesia and postoperative pain relief in lower limb procedures, alone or in conjunction with a femoral nerve block. Ultrasound guidance allows real-time imaging of drug distribution and reduces problems such as intra-neural and intravascular administration of local anaesthetic (LA). However, the success rate of ultrasound-guided sciatic nerve block is unpredictable. A recent study which included an electrophysiological follow-up of patients for six months found no adverse effects.[1] The success rate of intraneural injection of



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LA at the sciatic nerve was 95% compared to 63% with subparaneural injection.

*In vitro* investigations have shown that exposing a nerve lengthier than 2 cm or beyond three nodes of Ranvier to LA significantly lowers the compound action potential, resulting in a denser transmission blockade of the nerve.[2] No clinical investigations have been conducted to correlate the clinical characteristics of block induced in proportion to the length of nerve exposed to the LA solution. The definition of a total sensory block differs depending on the assessment technique. The pinprick method of assessing sensory block is subject to operator variability based on the pressure exerted and the instrument's sharpness. Using cutaneous current perception threshold (CPT) as a mode of testing for feeling eliminates operator errors and allows for the intensity to be tailored to each patient. Researchers have demonstrated that peripheral nerve stimulators are feasible devices for grading CPT and can be used as an objective method for assessing the sensory component of nerve blockade.[3]

The aim of this study was to determine the efficacy of expanding the length of the nerve exposed to local anaesthesia by performing a double-point injection at 2 and 6 cm above the division of the sciatic nerve and compare it with a single-point injection at 2 cm above the division using CPT to assess the completeness of sensory block.

## METHODS

This randomised controlled trial was conducted after approval from the Institutional Human Ethics Committee was obtained (vide approval number PG/2017/02/36 dated 25 February 2017), and trial registration was done with the Clinical Trials Registry – India (vide registration number CTRI/2017/12/010756, www.ctri.nic.in). The recruitment process was continuous sampling. Thirty patients in the age group of 18–60 years of either sex belonging to the American Society of Anesthesiologists (ASA) physical status I–III who were scheduled for surgeries of the lower limb were selected for the study after obtaining written informed consent for their participation in the study and the use of patient data in research and educational purposes. The study was carried out according to the principles of the Declaration of Helsinki, 2013. A thorough pre-anaesthetic checkup was performed as per the department protocol. Patients who did not consent, pregnant patients and patients with known allergies to LAs, coagulopathy, neurological deficits, neuromuscular diseases or infections at the injection site were excluded from the study.

Patients were randomly assigned to one of the two study groups, the single-point injection (Group SP) and the double-point injection technique (Group DP), by drawing sequentially numbered, coded, sealed, opaque envelopes containing a card with the computer-generated allocation number (1 = single point, 2 = double point). The envelopes were prepared by a third party who took no further part in the study. The investigators and the outcome assessor were blinded to the randomisation sequence before the block. An anaesthesiologist familiar with sciatic nerve blocks performed the blocks as per randomisation and took no further part in the study.

The skin surface to be tested was cleaned with alcohol, and two electrodes were applied to the sciatic nerve territory and connected to the neuromuscular monitor. The monitor was set to deliver an impulse at a frequency of 1 Hz with a pulse width of 300 μs. The intensity was increased in 1 mA increments until the patient perceived the 'electrical stimulus'. At this point, the current energy was increased further by 1 mA above the threshold and then reduced stepwise until the patient stopped to perceive the stimulus. Then, the current strength was increased again till the patient perceived the stimulus, and this point was recorded as the baseline CPT.

All patients were premedicated the night before and on the morning of surgery with oral alprazolam 0.5 mg and ranitidine 150 mg. On arrival in the operation theatre, monitors including noninvasive blood pressure, electrocardiogram (ECG) and pulse oximeter ($SpO_2$) were attached, and the baseline parameters were noted. An 18-G intravenous (IV) cannula was secured in the upper limb. In addition, a baseline cutaneous CPT was recorded using a neuromuscular monitor (TOF- Watch SX; Organon Ireland Ltd, Dublin, Ireland) on the lateral aspect of the ankle for all patients [Figure 1].

A high-frequency linear probe (HFL 50 xp) resonating at 15 MHz in the multi-beam mode (Sonosite Xporte; FUJIFILM Sonosite, Inc., Bothell, WA, USA) was used for all patients. Patients were placed in the prone position, and the transducer was placed in a transverse orientation between the tendons of the

hamstring muscle just above the popliteal fossa crease. The hyperechoic sciatic nerve is superficial and lateral to the popliteal artery and vein identified [Figure 2]. The nerve was scanned caudally to identify the tibial and common peroneal nerve divergence and then proximally to identify the sciatic nerve.

Block was performed using the in-plane technique, and the drug was injected into the subparaneural compartment in all patients. The nerve was scanned caudally to identify the injection point 2 cm proximal to the bifurcation of the tibial and common peroneal nerves [Figure 3a]. A 23-G spinal needle was inserted, and 20 mL of 1.5% lignocaine with adrenaline was injected in Group SP. In Group DP, the first injection point was identified as above and marked. The second injection point was marked by measuring 6 cm proximal from the point of the first injection, and the ultrasound probe was placed over both regions to identify the sciatic nerve. A 23-G spinal needle was advanced, and 10 mL of 1.5% lignocaine with adrenaline was injected each at the described points. The sciatic nerve was scanned proximally and distally from the point of injection to visualise the spread of LA around the nerve [Figure 3b]. The two points where LA spread around the nerve was visualised both proximally and distally from the points of injection were marked, and the length of the nerve bathed by the drug was then measured using a measuring tape. The time the needle was removed from the patient was noted as the block time (time zero). From this point onwards, patients were assessed every 5 min for 45 min as follows by an anaesthesiologist blinded to the technique chosen. Sensory block was assessed by using CPT. Baseline current was tested; if the patient could not perceive the baseline, this time, loss of baseline CPT was noted as the onset of the sensory blockade and the current energy was stepped up by 1 mA each time till the patient could perceive the stimulus. This was continued every 5 min until the patient could not perceive double the baseline CPT, and the time to loss of double the baseline CPT was noted. Sensory block was also assessed on a 3-point qualitative scale for the perseverance of cold sensation to ether-soaked cotton in all dermatomes of the sciatic nerve in the lateral aspect of the foot as follows: 2- perceives both touch and temperature, 1- perceives only touch and not the temperature, 0- perceives neither touch nor temperature. A complete sensory block was defined as achieving a sensory score of 1. Motor blockade was assessed on a 3-point scale for the power of plantar flexion as follows: 2- normal motor function (power

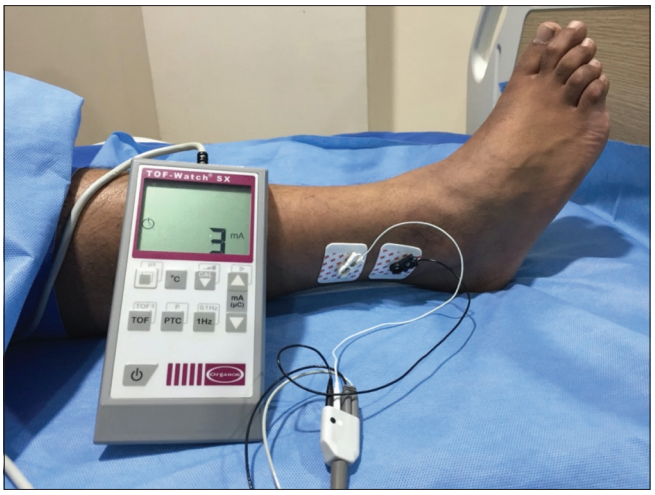


**Figure 1:** Train-of-four watch with the electrodes placed over the lateral aspect of the foot

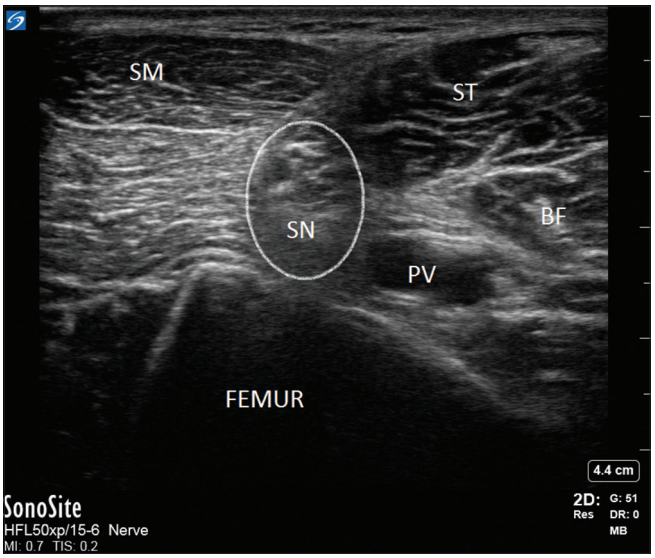


**Figure 2:** Ultrasonography image of the sciatic nerve. BF = biceps femoris, PV = popliteal vessels, SM = semimembranosus, SN = sciatic nerve, ST = semitendinosus

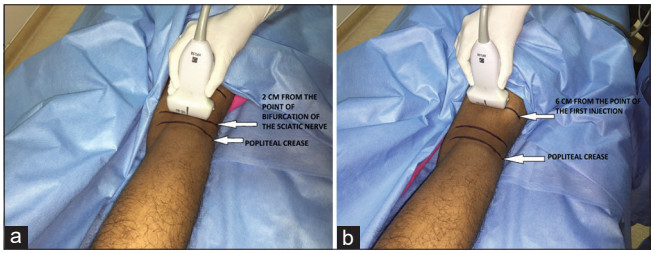


**Figure 3:** Ultrasound-guided sciatic nerve block: (a) point of first injection; (b) point of second injection

4/5, 5/5), 1- weakness against resistance (power 3/5. 2/5), 0- paresis/no motor power (power 0/5, 1/5). A score of 0 was considered a complete motor block. The inadequate block was considered if the patient did not achieve a sensory and motor score of 0 at the

end of 45 min from block time, and further anaesthesia management was left to the discretion of the attending anaesthesiologist.

At the end of the surgery, patients were transferred to the post-anaesthesia care unit and observed for half an hour, after which the patients were shifted to the ward. The patients were assessed for postoperative pain using verbal numeric rating score (VNRS) and block regression every 1 h. Tramadol, 50 mg IV, was given as rescue analgesia when the patient complained of pain (VNRS >3) and the time was noted. Duration of analgesia was defined as the time between the onset of the sensory blockade and the time of analgesic rescue requirement. Complications and side effects were also noted, including pruritus, nausea and vomiting. The study's primary outcome was the success rate; the onset of sensory blockade, duration of analgesia, time to complete sensory blockade, time to complete motor blockade, length of the nerve exposed to LAs and complications, if any, were our secondary outcomes.

The sample size was calculated using PS Power and Sample Size Calculation Software (version 3.0 January 2009) using 'the success rate of complete conduction blockade' as the primary outcome variable. Based on a previous study by Eldegwy *et al*., injection at the popliteal fossa before the sciatic nerve bifurcates produces a 73% success rate.[4] To find out a 25% (73% vs. 99%) increase in success rate in group DP as compared to Group SP (2 and 6 cm above the sciatic nerve bifurcation) with an error of 0.05 and power of 0.80, the calculated sample size was 27 patients in each group. The data was analysed using the Software Package for Social Sciences (version 20.0, 2011; SPSS Inc. Chicago, IL, USA). All parametric data were analysed using the independent *t*-test, and all nonparametric data were analysed using the Chi-square test.

## RESULTS

Sixty patients were screened for recruitment [Figure 4]. Three patients were excluded from the analysis in both groups due to pain at the graft site outside the sciatic nerve territory. The demographic data and baseline parameters were comparable between the two groups [Table 1].

The mean (standard deviation [SD][95% confidence interval (CI)]) time to loss of baseline CPT in group SP was 6.5 (3.2) (5.3, 8.3) min, and in group, DP was 5.3 (1.2) (4.7, 5.6) min ($P$ =0.080). The loss of baseline CPT did not occur in one patient in the DP group at 45 min. The mean (SD)(95%CI) time to loss of double the baseline CPT in group SP was 9.6 (6.5) (7.2, 12.7) min, and in group, DP was 8.4 (5.2) (6.1, 10.2) min ($P$ = 0.440). One patient in the SP group had lost the baseline CPT, but the loss of double the baseline CPT did not occur at the end of 45 min.

**Table 1: Patient factors and block characteristics**

| Variable | Group SP (*n*=30) | Group DP (*n*=30) | *P* |
|---|---|---|---|
| Gender (male:female) | 26:4 | 24:6 | 0.497 |
| ASA Physical Status (I:II:III) | 17:13:0 | 14:12:4 | 0.115 |
| Diabetic:Nondiabetic | 13:17 | 12:18 | 0.798 |
| Surgery pattern (bony:soft tissue: both) | 8:15:7 | 12:10:8 | 0.617 |
| Duration of surgery (min) | 65.83 (31.04) | 63.60 (34.52) | 0.790 |
| Block time (s) | 201.7 (136.4) | 247.8 (168.1) | 0.240 |
| Baseline CPT | 6.73 (5.09) | 6.70 (4.12) | 0.970 |

Values are presented as numbers and mean (standard deviation).
ASA=American Society of Anesthesiologists, CPT=Current perception threshold, DP=Double point injection, SP=Single point injection

The mean (SD) duration of analgesia in group SP was less than in group DP ($P$ = 0.02). The mean time to complete sensory blockade was more in the SP group than in group DP ($P$ = 0.06). Only one patient in the DP group, having lost both the baseline and double the baseline CPT, did not reach a sensory score of 2 at 45 min [Table 2]. The mean length of the nerve exposed was lesser in group SP than in group DP ($P$ = 0.012) [Table 2]. The mean time to complete motor blockade was lesser in the SP group than in the DP group ($P$ = 0.03). Only one patient in the SP group failed to achieve a motor score of 2 at 45 min after attaining a complete sensory block [Table 2].

## DISCUSSION

In this study, we found that compared to single-point injection, injecting LA at two points does not lead to a significant difference in the primary outcomes of the onset of sensory blockade and time to complete sensory blockade. However, secondary outcomes were found to have statistically significant differences. The length of the nerve exposed to LA was significantly longer in double-point injection than in single-point injection. The time to complete motor blockade and duration of analgesia were significantly prolonged.

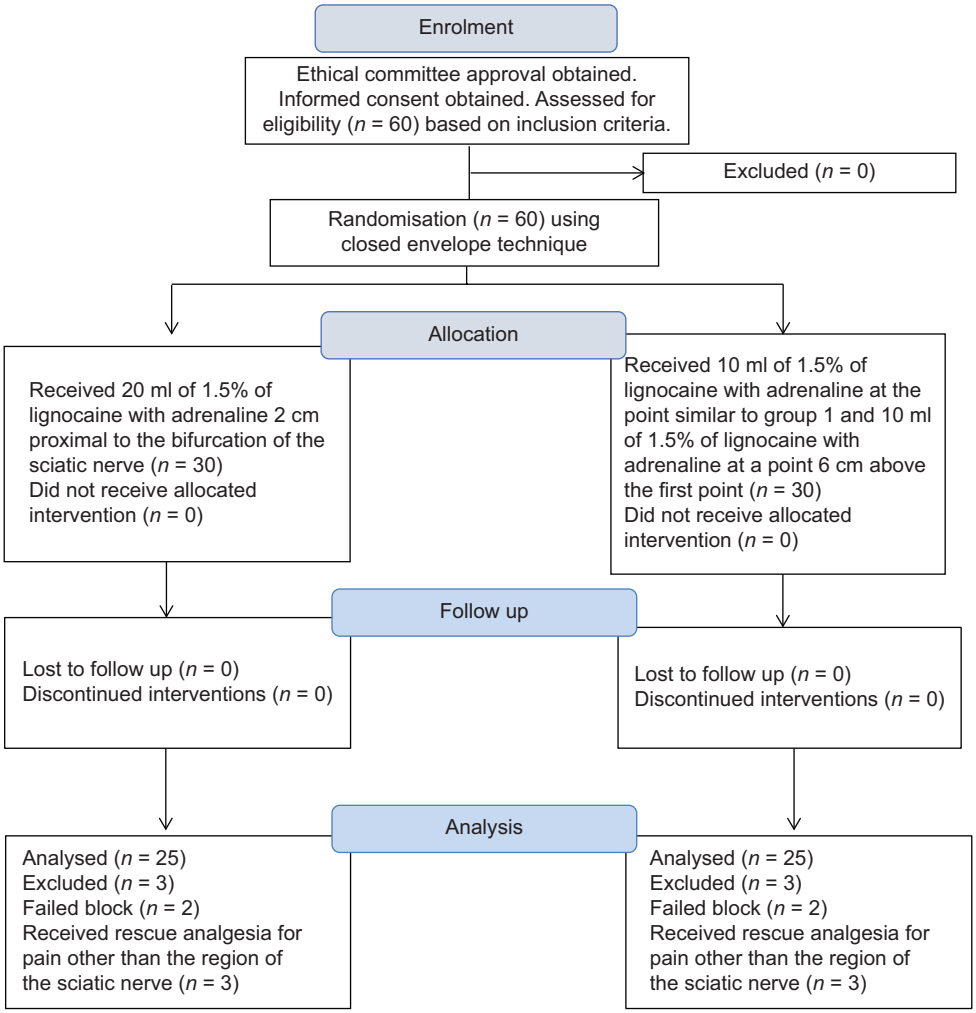


**Figure 4:** Consolidated standards of reporting trials (CONSORT) chart of patients

**Table 2: Block characteristics with analgesia**

| Variable | Group SP (*n*=30) | Group DP (*n*=30) | *P* |
|---|---|---|---|
| Time to complete sensory blockade (min) | 16.7 (11.3) (12.5, 22.3) | 12.1 (5.9) (9.5, 14.9) | 0.060 |
| Length of the nerve exposed (cm) | 18.8 (5.9) (16.3, 21.2) | 23.2 (7.2) (20.2, 26.3) | 0.012 |
| Time to complete motor blockade (min) | 20.9 (12.6) (15.7, 26.6) | 4.5 (9.9) (10.3, 18.4) | 0.030 |
| Duration of analgesia (min)* | 344.3 (125.9) (292.3, 396.3) | 20.4 (99.3) (379.4, 461.4) | 0.020 |

Values are presented as numbers and mean (standard deviation) (95% confidence interval). DP=Double point injection, SP=Single point injection

We found that the baseline CPT was lost relatively earlier in the DP group compared to the SP group. However, the difference between the groups was statistically insignificant ($P = 0.080$). The difference between the two groups concerning time to loss of double the baseline CPT was also insignificant ($P = 0.440$).

The time to complete sensory blockade, though faster in the DP group, was not statistically significant ($P = 0.061$). In contrast, multiple studies conducted in the past on ultrasound-guided sciatic nerve block showed that separate injections on the tibial and common peroneal components resulted in a faster sensory onset than a single-point injection proximal to the bifurcation.[5,6] This can be explained by the large diameter of the sciatic nerve that would cause LA to take time to reach the core fibres, resulting in a longer onset time for both sensory and motor blockade. As the nerve bifurcates into the tibial and common peroneal components, the nerve diameter reduces; so, when LA is injected, it reaches the core fibres faster, leading to a faster onset time. In our study, the sensory onset for both groups was the same as the subparaneural injection in both groups, resulting in a longer nerve length exposure and both nerve components getting bathed. A lot of anatomical studies show clarity on

injection sites in such blocks.[7-9] Therefore, we believe that exposing a longer nerve length to LA achieves an effect similar to blocking the nerve separately and more distally. It has been recently reported that the common peroneal and tibial components of the sciatic nerve are enveloped by their paraneural sheaths, separated in the centre by a septum. This unique internal structure allows the subparaneurally injected LA to spread uniformly along the length of the nerve when injected at or below divergence.[10]

The time to complete motor blockade was significantly faster in the DP group than in the SP group ($P = 0.039$). Also, the DP group bathed a significantly longer nerve length with an LA ($P = 0.012$). A literature search revealed no previous studies that associated nerve length with the motor blockade. This could be because when 20 mL of LA is injected at a single point within the perineurium, it may spread to the surrounding tissues due to increased hydrostatic pressure, resulting in lesser spread along the nerve, and injecting this volume at two different points results in uniform spread, making more LA available for better uptake by the neural tissue. A larger volume available around the more resistant and thicker motor nerve fibres may result in the earlier onset of complete motor blockade.

Duration of analgesia was prolonged in the DP group, and the difference between the groups was statistically significant ($P = 0.022$). This finding is similar to the results of Karmakar *et al*.[10] who reported that longitudinal neural exposure to LA was most significantly associated with the duration of the block. Patients undergoing split skin graft surgeries required a supplemental femoral nerve block for the graft site. Three patients in each of the two groups needed earlier rescue analgesia due to complaints of pain at the graft site and were not analysed for the duration of analgesia.

A study by Madsen *et al*.[11] showed that deposition of LA solution in the subparaneural space was a determining factor for rapid-onset and prolonged surgical anaesthesia. Our results support this further. Although statistically significant in the double-injection technique, the length of nerve exposed to LA was also substantial in the single-injection technique. We can infer that subparaneural compartmental injection is the best to achieve a good drug spread, with a faster clinical onset of sensory blockade even with the single-point injection. LA used in our study was lignocaine with adrenaline, contributing to a rapid onset of action. Both groups in our study had fast, complete sensory blockade, with no intergroup difference. Different studies have been published with varying volumes in sciatic nerves targeting acute and chronic pain, which are as low as 6.6 mL since most have used intraneural injections and ropivacaine.[12-14] We have used a total volume of 20 mL of 1.5% lignocaine in our study. We have not studied the chronic pain aspect in our research.

There are a few limitations in our study. First, current perception threshold (CPT) was unsatisfactory for testing conduction blockade since many patients in our study kept perceiving cold swab sensation even after the loss of double the baseline CPT. There is a scope for further studies to test and evaluate the usefulness of the CPT to assess sensory blockade and explore more clinically feasible options to do so. Second, in our study, the length of the nerve exposed to LAs was evaluated by ultrasound by tracing and measuring the hyperechoic drug spread, which may have operator bias. A more objective method for measurement is suggested for future studies.

## CONCLUSION

The ultrasound-guided popliteal sciatic nerve block with a double-point injection technique does not significantly shorten the time to complete the sensory block. However, the time to complete motor nerve block and duration of analgesia were significantly prolonged, which may be clinically beneficial for postoperative analgesia.

### Study data availability

De-identified data may be requested with reasonable justification from the authors (e-mail to the corresponding author) and shall be shared after approval as per the authors' institution policy.

### Financial support and sponsorship

Nil.

### Conflicts of interest

Dr. SP is on the journal's editorial board and was not involved in any decision-making process for this manuscript.

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