

Patterns of Cutaneous Innervation of the Dorsum of Foot with Unilateral and Bilateral Variations: A Cadaveric Cross-sectional Study from Eastern India

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ABSTRACT

Introduction: Variations of the sensory supply of the dorsum of the foot are not uncommon. Previous studies reported various types of variations and classifications of the sensory supply of the dorsum of the foot, but a repeated literature search revealed a paucity of data on the frequency of unilateral versus bilateral variations in sensory nerves over the dorsum of the foot in adult cadavers. Specifically, such studies were lacking in eastern India.

Aim: To record the frequency of unilateral versus bilateral variations of sensory nerves of the dorsum of the foot.

Materials and Methods: The present Cadaveric cross-sectional study was conducted among 30 cadavers (60 lower limbs) in the Department of Anatomy at Kolkata Medical College, Kolkata, West Bengal, India over a period of 10 months (October 2024-July 2025). Adult cadaveric lower limbs of both sides were selected for the current study. All cutaneous branches of nerves were exposed by fine dissection, and their area of distribution and variations of different branches were

recorded. The sensory supply of the dorsum of the foot was divided into five groups based on variations in the distribution of various branches (Group 1 - Group 5). Statistical analysis was done by descriptive statistics.

Results: Gross anatomical variations were recorded in the branching pattern of Superficial Peroneal Nerve (SPN), Sural Nerve (SN), Deep Peroneal Nerve (DPN) and saphenous nerve and the results of present study were classified into five groups Group 1-33 (55%), Group 2- 15 (25%), Group 3-6 (10%), Group 4-5 (8.33%) and Group 5-1 (1.67%). The present study also recorded unilateral and bilateral variations of sensory supply of the dorsum of the foot in 17 (28.33%) and 4 (6.67%), respectively.

Conclusion: The present study revealed that variations of cutaneous innervation of the foot were common but less frequent bilaterally. Such knowledge would be useful for Anatomists and Surgeons of the region during the dissection of the dorsum of the foot.

Keywords: Cadavers, Classification, Difference, Sensory, Significance, Types

INTRODUCTION

Variations in the sensory supply of the dorsum of the foot are not uncommon. Previous literature recorded the usual pattern of distribution of cutaneous nerves of the dorsum of the foot [1]. Not only that but different types of classifications of variations of sensory innervations of the dorsum of the foot has also been described [2-4]. Such variations have clinical significance, for example, grafting of sensory nerves [5] and avoiding iatrogenic nerve damage during planning various surgical incisions around the ankle [4,6,7]. Lee Y et al., stated in their article that the innervated First Dorsal Metatarsal Artery (FDMA) flap was a good alternative in reconstructive surgery for soft-tissue repair of the great toe [8]. So, knowledge about the sensory innervation of the dorsum of the foot is important. The sensory nerves of the dorsum of the foot are at risk while performing local anaesthesia, open reduction, internal fixation, or elevation of fasciocutaneous or fibular flaps for grafting on the leg, foot, or ankle [9,10]. Thus, the aim of the present study was to evaluate the bilateral pattern of sensory nerve supply among study specimens.

MATERIALS AND METHODS

The present Cadaveric cross-sectional study was conducted on 30 cadavers (60 lower limbs) in the Department of Anatomy of Kolkata Medical College, Kolkata, West Bengal, India, India from October 2024 to July 2025. Ethical clearance was obtained (no. MCK/KOL/IEC/NON-SPON/2672/2025 dated 12/02/2025).

Inclusion criteria: Adult cadaveric lower limbs of both sides were selected for the study.

Exclusion criteria: Lower limbs with diseases and surgical resections, skin and subcutaneous tissue damaged during storage or any gross deformities were excluded from the study.

Study Procedure

All cutaneous branches of nerves, including variations of different branches and their area of distribution, were exposed by fine dissection as per Cunningham's manual [11]. Single-blinding was done, and eight observers were recruited to record their observations. Interobserver reliability was calculated using Krippendorff's alpha and was 0.81. Nomenclature of the cutaneous supply of the dorsum followed in the present study was based on the study of Nayak VS et al., and the classification of sensory supply of the dorsum of the foot was adapted from the study of Wahee P et al., [2,12].

STATISTICAL ANALYSIS

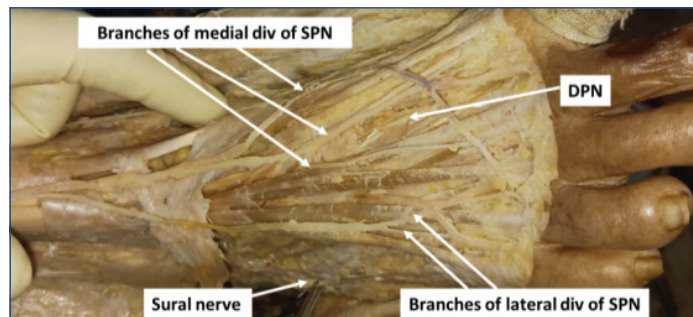
For statistical analysis, the relevant data was entered in Excel sheet and organised. Frequency and proportion was computed. Jamovi Computer Software (Version 2.6) was used for statistical calculation.

RESULTS

A total of 60 formalin-fixed lower limbs were dissected from 30 adult cadavers (age group between 60 and 85 years), and the branching pattern and distribution of cutaneous innervation of the dorsum were observed and recorded.

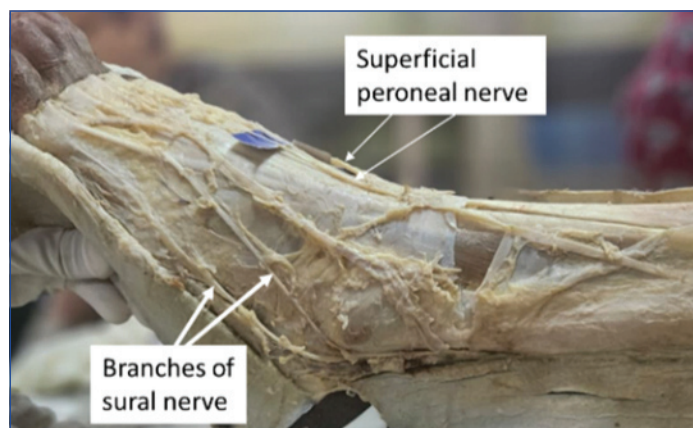
The sensory supply of the dorsum of the foot was divided into five groups based on variations in the distribution of the SPN, DPN, SN and saphenous nerve found in the current study.

The SPN was divided into the medial and lateral divisions. The medial division was further subdivided to supply the medial side of the great toe and the 2nd web space. The lateral division was forming digital branches to supply the third and fourth web spaces. The SN supplies the lateral side, and the saphenous nerve supplies the medial side of the foot, respectively. First web space was supplied by DPN [Table/Fig-1].



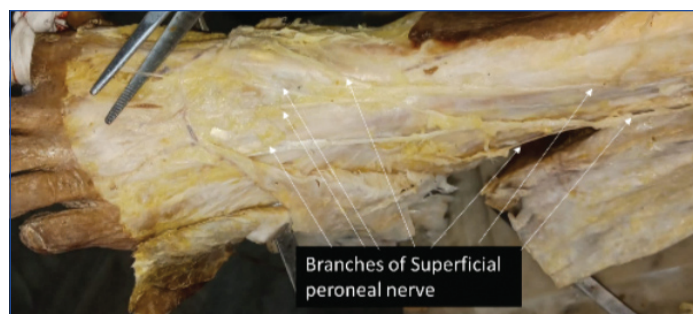
[Table/Fig-1]: Distribution of sensory nerves as described in Group 1.

The SN was supplying 3rd and 4th web spaces and lateral side of dorsum while SPN supplying 2nd web space and medial side of great toe after dividing into two divisions. The DPN, which supplies the first web space and the medial side of the dorsum, was supplied by the saphenous nerve [Table/Fig-2].



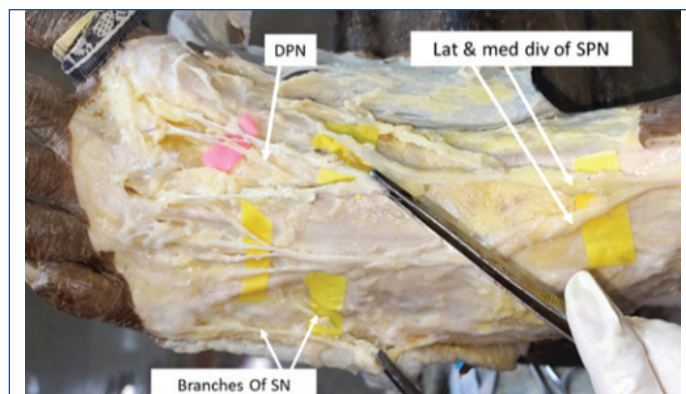
[Table/Fig-2]: Showing distribution of sensory nerves as described in Group 2.

SPN was supplying whole dorsum of foot including medial and lateral side except first web space which was supplied by DPN [Table/Fig-3].



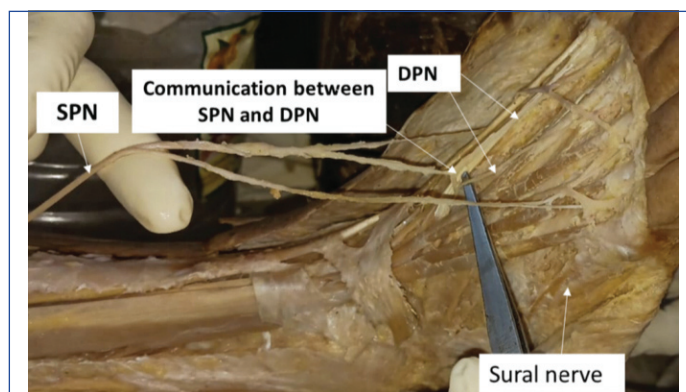
[Table/Fig-3]: Distribution of sensory nerves as described in Group 3.

In this group, 1st web space was supplied by the superficial and DPN. The 2nd and 3rd web spaces were supplied by the digital branches of the SPN. But the 4th web space was not only supplied by the SPN, but it was also supplied by the medial division of the SN. The lateral side of the dorsum was supplied by the lateral division of the SN. Medial side of dorsum supplied by saphenous nerve [Table/Fig-4].



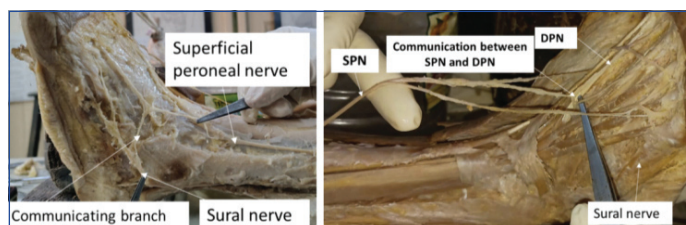
[Table/Fig-4]: Distribution of sensory nerves as described in Group 4.

The DPN communicates with the SPN by a communicating branch and then supplies the first web space. The DPN supplied 2nd web space as well. The 3rd and 4th web spaces were supplied by branches of the SPN [Table/Fig-5].



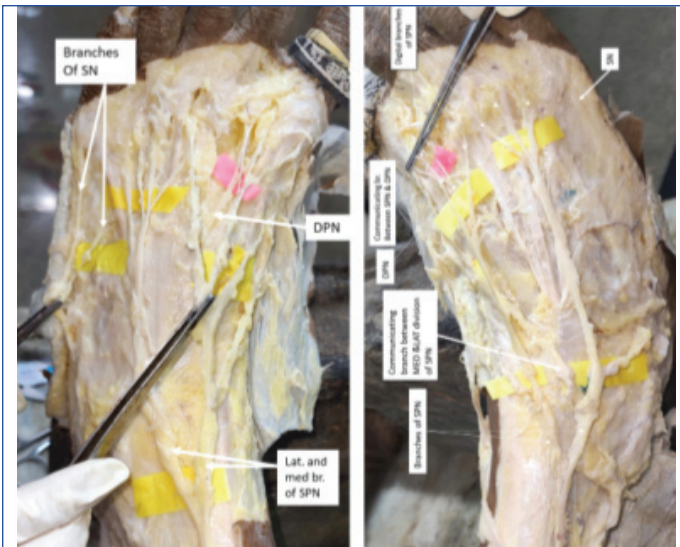
[Table/Fig-5]: Distribution of sensory nerves as described in Group 5.

Out of 30 dissected cadavers, only two cadavers with bilateral variations were found. Among them, one cadaver with bilateral variations showed cutaneous innervation which were not exactly the same for the right and left dorsum. [Table/Fig-6]. Here, the authors observed one communicating branch connecting the DPN with the SPN before supplying the first web space on the right dorsum but on the left dorsum in the same cadaver, the communicating branch was absent. In addition to the 1st web space, the DPN also supplies the 2nd web space on the right dorsum. On the left dorsum, the authors found that the SN communicated with the SPN and then supplied the 3rd web space. The present study also observed another cadaver with bilateral variations which were of the same type in both the dorsum (as shown in [Table/Fig-7]). Here, the first web space was supplied by both DPN and SPN. The present study also recorded communication between the lateral and medial divisions of the SPN [Table/Fig-8].

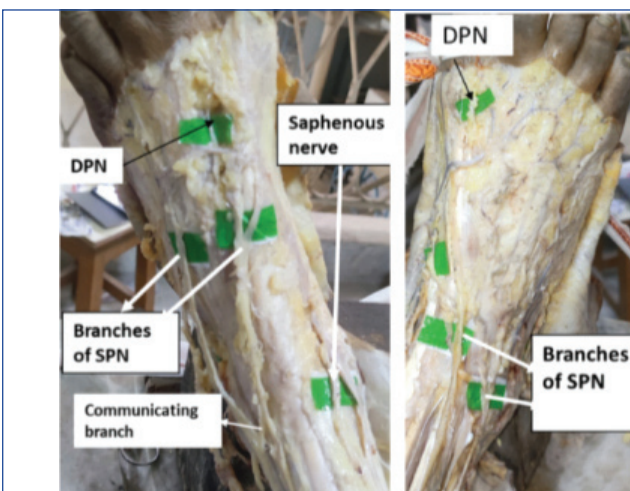


[Table/Fig-6]: Bilateral different variations between the right and left dorsum of the foot.

Sensory innervation in Group 1 (55%)- DPN supplying 1st and SPN supplying 2nd to 4th web spaces. Group 2 (25%)- 1st by DPN, 2nd by SPN and 3rd and 4th web spaces by SN. Group 3 (10%)-SPN was supplying whole dorsum of foot including medial and lateral side except first web space which was supplied by DPN. Group 4 (8.33%) 1st web space by SPN and DPN. 2nd and 3rd webs by SPN, 4th web by SPN and SN. Group 5 (1.67%)-1st web space by SPN and DPN. 2nd DPN, 3rd and 4th webs by SPN [Table/Fig-9].



[Table/Fig-7]: Bilateral same variation where first web space was supplied by both DPN and SPN.



[Table/Fig-8]: Unilateral variation- A communicating branch present between lateral and medial division of Superficial Peroneal Nerve (SPN).

Classification	Group 1	Group 2	Group 3	Group 4	Group 5
Number of dorsum	33	15	6	5	1
Percentage	55%	25%	10%	8.33%	1.67%

[Table/Fig-9]: Classification of sensory innervation of dorsum of foot with percentage. (N=60 (total number of right and left Dorsum)).

Unilateral and bilateral variations in sensory supply of dorsum of foot were recorded in 28.33% and 6.67%, respectively [Table/Fig-10].

Percentage of variations in sensory supply of dorsum of foot		Number of Left dorsa showing variations in sensory supply	Number of Right dorsa showing variations in sensory supply
Total unilateral variations, 17 (28.33%)		11 (18.33%)	6 (10%)
Total bilateral variations, 4 (6.67%)	Bilateral same variation {1 st web space was supplied by both SPN and DPN through communicating branch (shown in [Table/Fig-7])}	1 (1.67%)	1 (1.67%)
	Bilateral different variation {On Left dorsum- Communication between SPN and SN On Right dorsum- Communication between SPN and DPN (shown in [Table/Fig-6])}	1 (1.67%)	1 (1.67%)

[Table/Fig-10]: Table represent unilateral and bilateral variations of sensory supply of dorsum of Foot. (N=60 (Total number of left and right Dorsum)).

[Table/Fig-11] showed that most frequent variation of left dorsum was SN supplying lateral margin, 4th and 3rd web space (15%), whereas on right dorsum, communications between lateral and medial branch of SPN (11.66%) was found to be most frequent.

Types of variations	Left dorsum n (%)	Right dorsum n (%)	Right+Left dorsa N (%)
Communications between lat and med br of SPN	6 (10%)	7 (11.66%)	13 (21.7%)
Communication between SN and SPN	1 (1.67%)	0 (0%)	1 (1.67%)
Com bet SPN and DPN	1 (1.67%)	2 (3.33%)	3 (5%)
SN Supplying lat margin, 4 th and 3 rd web	9 (15%)	6 (10%)	15 (25%)
SN lat margin and 4 th web	3 (5%)	3 (5%)	6 (10%)
lat margin by SPN only	1 (1.67%)	5 (8.33%)	6 (10%)
1 st web by SPN and DPN and 2 nd web by DPN	0	1 (1.67%)	1 (1.67%)
Whole dorsum by SPN including lat and med margin except 1 st web	6 (10%)	0	6 (10%)

[Table/Fig-11]: Types of variations of cutaneous supply of foot with frequency (N=60).

Communicating branches between the lateral and medial divisions of the SPN were identified in 21.7% of cases in the present study, compared with 12% reported by Awari PS and Vatsalaswamy P [10] [Table/Fig-12] [2,4,10]. Medial dorsal cutaneous nerve and intermediate dorsal cutaneous nerve of their study corresponded to medial and lateral branch of SPN in present study.

Authors	Number of limbs studied	No. of limbs with communicating branches between SN and SPN	No. of limbs with communicating branches between DPN and SPN	No. of limbs with communicating branches between the medial and lateral division of SPN
Nayak VS et al., [2]	40	Not found	10%	-
Cheredath A et al., [4]	20	-	2 (33.33%)	-
Awari PS and Vatsalaswamy P [10]	50	-	-	6 (12%)
Present study	60	1 (1.67%)	3 (5%)	13 (21.7%)

[Table/Fig-12]: Comparison of communication patterns between sensory nerve branches on dorsum of foot with previous studies [2,4,10].

DISCUSSION

The sensory supply of the dorsum of the foot was clinically important for diagnosing polyneuropathy, entrapment syndromes, surgical planning around the ankle, injury prevention, and regional anaesthesia. Because these nerves were superficial, they were frequently injured during trauma or surgeries that led to various complications [13,14].

The SN was often used for nerve grafting because of its sensory nature and low donor site morbidity. This nerve exhibited significant anatomic variations, particularly in its origin and branching pattern. Such variations may affect the nerve harvesting technique. So, a sound knowledge of anatomic variations was required before planning SN grafting to prevent iatrogenic damage and ensure adequate graft length [15]. The SPN was also used as a nerve graft to treat peripheral nerve injury, with good clinical results [16].

Nayak VS et al., classified the sensory supply of the dorsum into four groups based on variations of the branching pattern of the SPN, DPN and SN in the following percentages: Group I in 45% specimens, Group II in 30%, Group III in 15%, and Group IV in 10% specimens [2].

Although, Group I of Nayak VS et al., recorded in 45% limbs, the present study found similar findings in Group 1 in 55% limbs. In addition, Group III of Nayak VS et al., corresponded to Group 2 of present study and was found in 25% cases [2].

Cheredath A et al., dissected 20 formalin fixed cadavers and classified cutaneous innervations of foot into five types based on variations of branching pattern of SPN, DPN, SN and saphenous nerve in following percentage-variation I in 10%, variation II in 5%, variation III in 5%, variation IV in 5% and variation V in 5% limbs [4]. Group 2 of the present study was similar to the variation I of Cheredath A et al., study [4]. But we recorded this variation in 25% cases.

Wahee P et al., studied 60 lower limbs from 30 cadavers and classified the sensory supply of the dorsum of the foot into six types [12]. They observed Type 1 in 53.3% limbs, Type 2 in 28.3%, Type 3 in 8.3% limbs, Type 4 in 3.3%, Type 5 in 5%, and Type 6 in 1.7% limbs. Of the six types, Type 1 was the most common, and Type 6 the least common. The present study classified sensory innervation in five groups. The type 5 in the present study corresponded to type 6 of Wahee P et al., [12].

Unlike the studies of Cheredath A et al., (33.33% cases communications between SPN and DPN) [4] and Nayak VS et al., (10% cases communications between SPN and DPN) [2], the present study noted communication between SPN and DPN in 5% cases (shown in [Table/Fig-11]).

Drizenko A et al., found communication between SPN and SN in 58% cases [17]. Sharma S et al., revealed this communication in 30% limbs [18], but the present study observed this variation only in 1.7% limbs [Table/Fig-11].

Heo Y et al., investigated 130 feet and they classified SN into five groups (A-E) [19]. The present study observed a variation similar to Heo Y et al., Type D (3rd and 4th web spaces supplied by SN) in 25% cases. The present study also noted in 10% cases, Type E of Heo Y et al., classification, where SN distribution was absent along the lateral margin of foot [19].

Limitation(s)

The present study was conducted at a single institution in Eastern India, which may limit its generalisability. Similar multicentric studies with larger sample sizes may be conducted in the future to reduce the margin of error.

CONCLUSION(S)

The present study revealed that variations of cutaneous innervation of the foot were common but less frequent bilaterally. The results of the present study may help the surgeon avoid iatrogenic nerve injury on the dorsum of the foot and minimise surgical complications around the ankle.

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