Redefining the Superficial Peroneal Nerve: Stimulation Technique, Normal Values, Clinical Significance

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Abstract- Polyneuropathy diagnosis often depends on sural sensory response values. The superficial peroneal nerve may serve as an alternative. This study aims to establish techniques for studying the superficial peroneal nerve and its branches while documenting normative values. It also seeks to compare nerve conduction values with those of the sural sensory nerve. This study attempts to validate the reliability of the superficial peroneal sensory nerve for sensory neuropathy diagnosis by comparing it with the sural nerve in diabetics. The first part studies 23 healthy subjects aged 20 to 50. Nerve conduction studies were conducted on sural and superficial peroneal nerves and parameters were collected. The second part examines the trunk of the superficial peroneal sensory response and sural nerves in 13 diabetic patients with clinically diagnosed diabetic polyneuropathy, comparing values with age-matched healthy controls. In the first part which included 23 healthy subjects, mean values for distal latency, amplitude, and conduction velocity were documented for the trunk of the superficial peroneal nerve, IDCN, MDCN, and sural nerve. In the second part, diabetic patients of which 6 were males and 7 were females between the ages 50 and 80 years demonstrated lower amplitudes in both the trunk of the superficial peroneal nerve and sural nerve compared to healthy controls. This study substantiates the reliability of the trunk of the superficial peroneal sensory nerve in sensory nerve conduction testing. The results suggest that this method could be used as an alternative to sural nerve studies in evaluating patients with peripheral neuropathy.

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Introduction

The diagnosis of sensory or mixed polyneuropathy depends significantly on the values of the sural sensory response as the conventional practice and as reported in the literature (1-3). Occasionally, the electrophysiologist has difficulty in eliciting the sural response in some patients because of non-neurologic causes such as incisions from previous surgery, sural nerve biopsy, or trauma. Some authors suggest the evaluation of the superficial peroneal nerve instead of the sural nerve for that purpose (4-7). There is a paucity in the literature of studies defining the nerve conduction studies of the superficial peroneal nerve or its branches, differentiating which is the better nerve to study, and documenting normative values for each branch (8-10).

This study aims to define the technique to study the trunk of the superficial peroneal nerve and its branches: the intermediate dorsal cutaneous nerve (IDCN) and the medial dorsal cutaneous nerve (MDCN), to document the normative values (distal latency, amplitude, and conduction velocity) in selected decades, and to compare the nerve conduction values to that of the sural sensory nerve. To further confirm the reliability of the use of the superficial peroneal sensory nerve in diagnosing pathology, this study will compare the nerve conduction variables of the superficial peroneal sensory nerve and sural nerve in diabetic patients compared to age-matched healthy controls (11-15).

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Materials and Methods

This prospective study conducted at the American University of Beirut Medical Center received ethical approval from the Institutional Review Board (IRB).

Written informed consent was obtained from all participating patients. Additionally, authorization for the disclosure of individuals in photographs was secured.

This study includes two parts:

The first part involves studying twenty-three normal subjects (11 men) between the ages of 20 and 50 years with a negative medical history for disease or medication use. The sural and superficial peroneal nerves were studied. The sural nerves were assessed on both lower limbs by antidromic stimulation at the posterolateral aspect of the leg with recording from the region lateral to the Achilles tendon and medial to the lateral malleolus (figure 1). The superficial peroneal sensory response was obtained in three different techniques.

1. Trunk to trunk recording:

The recording electrode was placed medial to the lateral malleolus anteriorly 4 cm above the ankle with stimulation 8 cm proximally at the tibial shaft (figure 1).

2. Trunk to intermediate dorsal cutaneous nerve

The recording electrode was placed just 2 cm medial to the lateral malleolus anteriorly with stimulation 12 cm proximally at the tibial shaft (figure 1).

3. Trunk to medial dorsal cutaneous nerve

The recording electrode was placed at the midpoint between the first and second toes 3 cm proximally with stimulation at the ankle anteriorly (Figure 1D). The distal latencies, amplitude, and conduction velocities for the different stimulation techniques were collected for analysis.

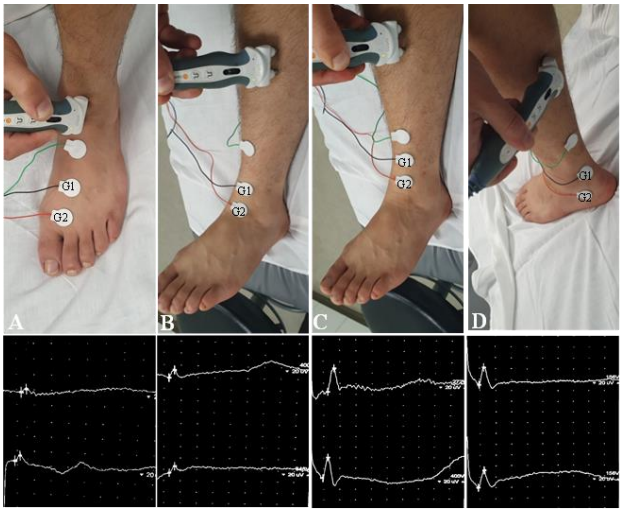

Figure 1. Scheme of electrode placement and site of stimulation in the four tested nerves of the study. Time base 2ms/division; Sensitivity 20µV/division

(A) MDCN recording; (B) IDCN Recording; (C) Trunk recording; (D) Sural Recording

Nerve conduction readings from left to right: MDCN recording; IDCN Recording; Trunk recording; Sural Recording

The nerve conduction studies were performed by the primary investigator, with the help of the laboratory technicians, on the VIASYS Healthcare Neurocare-Nicolet EDX Viking electrophysiology machine. The settings are as follows:

- Filter Setting: 10-10,000 kHz
- Time Base: 2 ms/division
- Stimulus Intensity: 150-300 V (1.5x maximal amplitude of the response).
- Stimulus Duration: 0.1 ms
- Sensitivity: 20 µV/division
- Number of averaged responses: 0-5 stimuli
- Skin Temperature: 37º C

The population included 11 healthy men and 12 healthy women between the 3rd and 5th decade of life. These healthy individuals were collected from healthy personnel from the medical center.

The cohort should be healthy individuals with no history of a medical illness, not suffering from any symptoms during the procedure, and not on any medical

therapy.

The cohort should have normal motor power and sensory examination in the legs and preserved Achilles deep tendon reflex when examined by the primary investigator during the testing procedure.

The second part of the study involves studying the trunk of the superficial peroneal sensory response and sural nerves in diabetic patients with diabetic polyneuropathy diagnosed clinically and by conventional nerve conduction studies. The values in these patients will be compared to age-matched healthy controls for the purpose of evaluating whether the trunk of the superficial peroneal sensory response reflects the same pathology seen in the sural nerves. For this part of the study, we examined clinically and electrophysiologically 13 healthy adults between the 6th, 7th, and 8th decades of life. These were compared with 13 patients in the same age group diagnosed by the investigators in the clinic to suffer from diabetic polyneuropathy which was confirmed by their electrophysiological studies performed during their routine investigation.

The data was analyzed via the IBM SPSS software to calculate the mean, median, standard deviation, and p-value.

Results

For the first part of the study, the cohort consists of 11 healthy males and 12 healthy females adding up to 46 limbs. The nerves studied were the sural sensory nerve, the trunk of the superficial peroneal nerve, the intermediate dorsal cutaneous nerve (IDCN), and the medial dorsal cutaneous nerve (MDCN) of the superficial peroneal nerve as detailed in the materials and methods section above. 7 males and 6 females were in the 3rd decade of life, 4 males and 4 females in the 4th decade, and one male and one female in the 5th decade. The minimal and maximal distal sensory latencies, sensory amplitudes, and sensory conduction velocities of the all the nerves were measured. The mean and standard deviation were calculated (Table 1).

Table 1. Summary of sensory nerve conduction parameters

		Trunk	IDCN	MDCN	Sural
Distal Latency (msec)	Mean	2.1 ± 0.4	2.5 ± 0.6	2.3 ± 0.4	2.3 ± 0.4
	Minimum	1.2	1.5	1.5	1.4
	Maximum	3.2	3.8	3.4	3.4
Amplitude (µV)	Mean	19 ± 8.5	13 ± 5.7	9 ± 7.1	22 ± 9.5
	Minimum	8	5	2	6
	Maximum	44	26	48	55
Conduction Velocity (m/s)	Mean	57 ± 7.7	53 ± 8.4	50 ± 9.0	55 ± 7.6
	Minimum	44	36	34	42
	Maximum	78	79	75	76

The mean distal latency of the trunk of the superficial peroneal nerve was 2.1ms, the IDCN was 2.5 ms, the MDCN 2.3 ms, and the sural nerve 2.3 ms. The mean amplitude of the trunk of the superficial peroneal nerve was 19 µV, the IDCN was 13 µV, the MDCN 9 µV, and the sural nerve 22 µV. The mean conduction velocity of the trunk of the superficial peroneal nerve was 57 m/s, the IDCN was 53 m/s, the MDCN 50 m/s, and the sural nerve 55 m/s.

For the second part of the study, the healthy cohort were 6 males and 7 females between the ages 50 and 80 years. The minimal and maximal distal sensory latencies, sensory amplitudes, and sensory conduction velocities of the all the nerve were measured. The mean and standard deviation were calculated (Table 2). The mean distal latency of the trunk of the superficial peroneal nerve and sural nerve were 2.1 ms and 2.4 ms respectively. The mean amplitude of the trunk of the superficial peroneal nerve and sural nerve were 14.3 µV and 15.1 µV respectively.

The mean conduction velocity of the trunk of the superficial peroneal nerve and sural nerve were 56.4 m/s and 52.5 m/s respectively.

The diabetic cohort was 11 males and 2 females between the ages of 50 and 80 years.

The minimal and maximal distal sensory latencies, sensory amplitudes, and sensory conduction velocities of all the nerves were measured. The mean and standard deviation were calculated (Table 2). The mean distal latency of the trunk of the superficial peroneal nerve and sural nerve were 2.1 ms and 2.4 ms respectively. The mean amplitude of the trunk of the superficial peroneal nerve and sural nerve were 8.0 µV and 8.0 µV respectively. The mean conduction velocity of the trunk

of the superficial peroneal nerve and sural nerve were 51.0 m/s and 48 m/s respectively.

Table 2. Nerve conduction study parameters stratified as healthy versus diabetic patients

		Healthy		Diabetes Mellitus	
		Trunk	**Sural**	**Trunk**	**Sural**
Distal Latency (msec)	Mean	2.1 ± 0.4	2.4 ± 0.4	2.1 ± 0.4	2.4 ± 0.5
	Minimum	1.2	1.6	1.4	1.7
	Maximum	2.8	3.2	3.0	3.2
Amplitude (µV)	Mean	14 ± 8.1	15 ± 8.1	8 ± 4.2	8 ± 4.4
	Minimum	4	1	2	1
	Maximum	34	33	20	16
Conduction Velocity (m/s)	Mean	56 ± 10.1	53 ± 7.7	51 ± 8.9	48 ± 6.8
	Minimum	40	40	38	39
	Maximum	76	65	75	61

Discussion

Some authors have reported that the superficial peroneal sensory nerve and its distal branches are more useful as diagnostic criteria for peripheral neuropathy than the sural nerve (7,11,13). Furthermore, we encounter occasions where the sural sensory nerve is difficult to elicit for no specific reason, such as leg edema, previous surgery on the ankle, or thickened skin. In these cases, the value of the superficial peroneal nerve can help in defining a normal versus pathologic nerve conduction study (7,13). Our study reveals similar values for the distal sensory latency between the trunk of the superficial peroneal sensory nerve and the IDCN, MDCN, and sural sensory nerve. These values were comparable to the values described in the literature (8-10,13) and slightly shorter than some authors (6).

The conduction velocities of the responses in our population were the highest in the trunk of the superficial peroneal nerve at 57 m/s and the sural nerve at 55 m/s compared to lower values for the branches of the superficial peroneal nerves at 51 m/s (Table 1). This discrepancy in the conduction velocity has also been reported previously suggesting faster conduction velocity of the larger nerves; the trunk and sural nerves, compared to the thinner branches (4,7,13). The major finding of our study is the difference in amplitude between the different nerve studies as well as between the different genders (10). The mean amplitude of the trunk of the superficial peroneal nerve was similar to the sural nerve (19 versus 22 µV) while the mean amplitude of the IDCN and MDCN were significantly lower than that of the trunk of the superficial peroneal nerve at 13 and 9 µV respectively. It is interesting to notice that the mean amplitude of the trunk was the summation of the amplitude of the branches of the superficial peroneal nerve i.e., IDCN and MDCN (Table 2). The difference in the amplitude between the distal branches of the superficial peroneal sensory nerves and the trunk is similar to the results published by previous authors confirming the reliability of our numbers (5,8-10). Some authors claim studying the intermediate dorsal cutaneous nerve of the superficial peroneal nerve and comparing it to the sural nerve revealing similar amplitudes of the sensory responses. Their values averaged at 21 µV which is exactly the number we found upon studying the trunk of the superficial peroneal nerve. We presume that these authors are in fact studying the trunk of the superficial peroneal nerve rather than the IDCN. This raises the issue of the technical aspects in the study of the superficial peroneal nerve (6,8-10,13).

Our study revealed that the mean amplitude of the response of the trunk of the superficial peroneal sensory nerve was similar in both males and females (17 and 19 µV respectively) as well as the sural response in males (16 µV); while the sensory amplitude of the sural response was higher in the female population (26 µV) (Table 3). We theorize that this discrepancy may result from repeated trauma on the feet of young men compared to women, different footwear between the sexes, and possibly because of thinner skin in the female gender (10). We conclude that the distal sensory latencies of the trunk of the superficial peroneal nerve as well as its distal branches and that of the sural nerve are comparable.

Table 3. Mean sensory amplitude stratified according to gender

Amplitude (μV)	Females	Males
Trunk of the superficial peroneal nerve	19	17
Sural sensory nerve	25.5	16

The conduction velocities of the trunk of the superficial peroneal nerve and the sural nerve are faster than the distal branches of the superficial peroneal nerves (IDCN, and MDCN).

The amplitude of the trunk of the superficial peroneal nerve and sural nerve are comparable with no statistically significant difference (P>0.05) and higher than the distal branches of the superficial peroneal nerves because of the larger fiber number. We found that the amplitude of the trunk of the superficial peroneal nerve is the summation of its distal branches.

The ease in eliciting a response from the trunk of the superficial peroneal nerve as well as its larger amplitude make it a more reliable sensory nerve conduction test than assessing the distal branches, the IDCN and MDCN. Our values are very similar to those published in the literature confirming the reliability of the technique. We recommend standardizing the values of the trunk of the superficial peroneal nerve and using it routinely in studying the sensory fibers of the feet as its response is easier to elicit, has more reliable values, and similar to the already standardized sural sensory response. To further confirm the reliability of using the nerve conduction studies of the trunk of the superficial peroneal nerve in diagnosing peripheral neuropathies, we performed nerve conduction studies of the trunk of the superficial peroneal nerves and compared it to the neurography of the sural nerves in patients with definite diabetic polyneuropathy.

Patients with diabetic polyneuropathy had a mean sural amplitude of 8.0 μV compared to 15.0 μV in healthy controls which was statistically significant (P=0.023). The mean sural distal latency and mean sural conduction velocity did not differ significantly between healthy controls and diabetic patients (P=0.27 and P=0.34 respectively). Patients with diabetic polyneuropathy had a lower mean superficial peroneal trunk amplitude compared to healthy age-matched controls (8.0 μV versus 14.0 μV) (P=0.024). The distal sensory latencies and sensory conduction velocities of the trunk of the superficial peroneal nerves did not differ between patients with diabetic polyneuropathy compared to aged-matched controls (P=0.15 and P=0.18 respectively). This result confirms that the neurography of the trunk of the superficial peroneal sensory response can differentiate patients with diabetic neuropathy from their aged-matched controls at least by its amplitude (1,7,11,13,15).

It is impressive to conclude that the distal sensory latencies, sensory amplitudes, and sensory conduction velocities between the trunk of the superficial peroneal sensory responses and sural responses did not differ statistically in diabetic patients. This indicates that the pathology revealed in the nerve conduction study of the trunk of the superficial peroneal nerve mirrors that of the sural nerve in diabetics in this age group. This concludes that we can use the nerve conduction study of the trunk of the superficial peroneal nerve in the same fashion we use the nerve conduction studies of the sural nerves in studying and evaluating patients with peripheral neuropathy at least in diabetic patients. We recommend a more extensive study of these nerves in patients with polyneuropathies of different etiologies.

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