

Anatomical Variations in Formation of Sural Nerve in Adult Indian Cadavers

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ABSTRACT

Background: Sural nerve is formed by communication of medial sural cutaneous nerve, that arise from tibial nerve in popliteal fossa and peroneal communicating nerve, a branch directly from common peroneal nerve or from lateral sural cutaneous nerve. The sural nerve is universally recognized by surgeons as a site for harvesting an autologous nerve graft and for nerve biopsies in case of neuropathies.

Setting and Design: Anatomy department and an observational study.

Statistical Analysis: The Mean, Standard Deviation, relevant percentages and p value was calculated by Chi-square test.

Material and Methods: The study consists of 50 lower limb specimens in 25 cadavers. All the male and female complete cadavers were included in the study. The data was collected by dissection method by using dissection instruments and

parameters (measurements) were obtained by using measuring tape.

Results: The sural nerve complex was dissected and observed in 50 formalin fixed lower limb specimens. Study was done in 16 male and 9 female cadavers. Three types of formation of sural nerve were observed were - Type A was seen in 36 specimens (72%) of cases. Type B was seen in 14 specimens (28%) of cases. Type C sural nerve was not found in present study. Site of union of components of SN was seen in the upper 3rd of leg in 5.6%, in middle 3rd it was in 33.3% and in lower 3rd it was in 58.3% of cases. The length of the sural nerve shows a wide range from 2 cm to 32 cm. The symmetrical distribution was seen in 62.5% in males and 55.6% in female.

Conclusion: The normal anatomy and variations may help to guide during surgeries in the region.

Key words: Sural nerve complex, Lateral sural cutaneous nerve, Medial sural cutaneous nerve, Peroneal communicating nerve

INTRODUCTION

The Sural Nerve (SN) is a sensory nerve of lower limb that supplies lower posterolateral part of leg and lateral part of dorsum of foot [1-3]. Sural nerve is formed by communication of Medial Sural Cutaneous Nerve (MSCN), that arise from tibial nerve in popliteal fossa and Peroneal Communicating Nerve (PCN), a branch directly from common peroneal nerve or from Lateral Sural Cutaneous Nerve (LSCN). Sural nerve may be formed without communication between these branches and then it is only a continuation of medial sural cutaneous nerve. The sural nerve formation is highly variable [4].

The sural nerve is universally recognized by surgeons as a site for harvesting an autologous nerve graft [5]. It is particularly advantageous as it provides a generous length of expandable nerve and is of ideal caliber for revascularization for interfascicular graft replacement [1]. Pieces of sural nerve are often used for nerve grafts in procedures such as repairing nerve defects resulting from wounds and located by surgeons in relation to the small saphenous vein. Because of variations in the level of formation of sural nerve, the surgeon may have to perform incisions in both the legs and then select the better specimen [6]. Sural nerve grafts are used to restore the muscle tone in Facial nerve palsy. Sural nerve is widely used for electrophysiological studies to know the conduction velocity distribution as compared to the fiber size distribution. SN is considered as suitable for nerve biopsies in case of neuropathies, since it is superficial, readily accessible and largely sensory [4]. However studies have shown considerable variations among the specimens from different cadavers as well as between the right and left legs from the same cadavers [7, 8].

Hence, this study was done to know the anatomy of the sural nerve complex, variations & measurements were important in carrying out these procedures and were helpful for planning operative approaches that minimize the risk of sural nerve injury.

MATERIAL AND METHODS

This study included 50 lower limb specimens in 25 cadavers. All the male and female complete cadavers were included in the study. The data was collected by dissection method by using dissection instruments and parameters (measurements) were obtained by using measuring tape. The dissection was done as follows:

A horizontal incision was made at the junction of middle and lower 1/3rd of the thigh and another at lower end of the lateral malleolus. These two incisions were joined by vertical incision. A thin flap of skin was reflected on either side. Then the superficial fascia was exposed in distal 1/3rd the leg, the sural nerve was identified along with the side of lesser saphenous vein. Sural nerve was then traced upwards to study its formation and site of piercing the deep fascia and this point was measured from bony point, fibular head. The deep fascia was then exposed and the medial sural cutaneous nerve was traced between the two heads of gastrocnemius muscle, till its origin from the tibial nerve in popliteal fossa. The peroneal communicating branch was then traced upwards from the point of union with medial sural cutaneous nerve up to its origin either from lateral sural cutaneous nerve or directly from trunk of common peroneal nerve. The origin of components of sural nerve complex was noted. The nerves were cleaned by removing enough fat. After cleaning the following points were noted.

1. Presence or absence of all the components of the sural nerve complex.
2. The origin, course of sural nerve and distance was measured at which SN pierces the deep fascia from fibular head.
3. Length of sural nerve was measured from its formation till lateral malleolus by measuring tape in centimeters.
4. Symmetry in the formation of sural nerve.

Formation of SN was broadly classified into three Types A, B, and C [9]. In Type A, the SN was formed by the union MSCN of tibial nerve and PCN of CPN. Occasionally the PCN of the CPN joins the MSCN by more than one branch. The union of these nerves occurs in the lower half of the leg. In Type B, the SN was continuation of the MSCN and the PCN was absent. In Type C the SN was formed only by the PCN. The data obtained were recorded and were analysed and compared with previous studies.

STATISTICAL ANALYSIS

The Mean, Standard Deviations, relevant percentages and p value was calculated by Chi-square test.

RESULTS

The sural nerve complex was dissected and observed in 50 formalin fixed lower limb specimens. Study was done in 16 male and 9 female cadavers. The components which formed the sural nerve were determined as MSCN, LSCN, PCN and SN proper.

Sural nerve is formed by the union of MSCN and PCN lying with the small saphenous vein near the lateral margin of tendocalcaneus, it continues distally to the interval between the lateral malleolus and the calcaneus. This was observed in 72% of specimens.

Three types of formation of sural nerve observed

Type A was seen in 36 specimens (72%) of cases [Table/Fig-1]. Type B was seen in 14 specimens (28%) of cases [Table/Fig-2]. Type C sural nerve was not found in present study. There was nearly equal distribution in the type of formation in both the sexes [Table/Fig-1]. In the present study, the sites of union of the MSCN with PCN components were observed. In Type A the site of union of the MSCN and the PCN is extremely variable. This union may take place anywhere between the popliteal fossa and the lateral malleolus. In recording the observations, each leg was considered to be divided into 3 parts. The site of union was seen as follows: Site of union of components of SN was seen in the upper 3rd of leg in 5.6%, in

popliteal fossa in one specimen, in which MSCN was very short. It was either the components of SN or sural nerve itself which was entrapped between the two heads of gastrocnemius.

Length of sural nerve from its formation till lateral malleolus

The present study showed a wide range of difference in the length of the sural nerve. In males it was measuring between 7-32 cm on right and 8-26 cm on left. In females it was measuring 8-32 cm on right and 10-32 cm on left (Mean \pm 2 Standard Deviation = 19.02 \pm 15.32).

Point at which sural nerve pierces the deep fascia

SN is formed either by the communication of MSCN with PCN or as a direct continuation of MSCN. Later it pierces the deep fascia to become superficial in further course. In the present study the point at which SN pierced deep fascia was measured from the level of fibular head with the help of a measuring tape. The value varied from 5 cm to 32 cm (Mean \pm 2 Standard Deviation = 20.86 \pm 12.88).

Type of distribution of sural nerve

The Symmetrical group had the same type of formation in both the legs, while the asymmetrical group had the anastomotic type (A) in one leg and a non-anastomotic type (B or C) in the other leg. In the present study, the symmetrical distribution was seen in 62.5% in males and 55.6% in female. Symmetrical Type A form of SN was seen in 9 cases of male and in 2 cases of female. When compared in both the sexes, Type A was commonly found. Distribution of Symmetry and Asymmetry is statistically similar between male and female [Table/Fig-3].

DISCUSSION

The components which formed the sural nerve were determined as MSCN, LSCN, PCN and SN proper [3, 10]. It is a cutaneous branch from tibial nerve in the popliteal fossa, descends between the two heads of gastrocnemius muscle and pierces the deep fascia in the

Observations in SN	Male						Female						Total	
	Left		Right		Total		Left		Right		Total			
Formation	No	%	No	%	No	%	No	%	No	%	No	%	No	%
A	12	75.0	12	75.0	24	75.0	6	66.7	6	66.7	12	66.7	36	72.0
B	4	25.0	4	25.0	8	25.0	3	33.3	3	33.3	6	33.3	14	28.0
Total	16	100.0	16	100.0	32	100.0	9	100.0	9	100.0	18	100.0	50	100.0

[Table/Fig-1]: Observations in formation of sural nerve

Forming Location	Male (n=24 limbs)				Female (n=12 limbs)				Total (n=36)	
	Left(12)		Right(12)		Left (6)		Right(6)			
	No	%	No	%	No	%	No	%	No	%
Upper 3 rd of leg	1	8.3	1	8.3	0	0.0	0	0.0	2	5.6
Middle 3 rd of leg	4	33.3	5	41.7	2	33.3	0	0.0	11	33.3
Lower 3 rd of leg	7	58.3	6	50.0	4	66.7	5	83.3	22	58.3
In popliteal fossa	0	0.0	0	0.0	0	0.0	1	16.7	1	2.8
Total	12	100.0	12	100.0	6	100.0	6	100.0	36	100.0

[Table/Fig-2]: Site of union of SN components

middle 3rd it was in 33.3% and in lower 3rd it was in 58.3% of cases. In males it was more commonly in the middle 3rd and in females it was in the distal 3rd of leg. Site of union was seen with in popliteal fossa in 2.8% of cases [Table/Fig-2].

Other findings of sural nerve

Sural nerve formation was explained according to the origin as of three types and also its difference in levels of formation in the leg. In one of the specimen there was twice communication and hence twice formation of sural nerve. SN was formed within the

	Male	Female
Symmetry	10 (62.5%)	5(55.6%)
Asymmetry	6(37.5%)	4(44.4%)
Total	16(100.0%)	9(100.0%)
Inference	Distribution of Symmetry and Asymmetry is statistically similar between male and female with p=1.000 (Chi-square test)	

[Table/Fig-3]: Distribution of symmetry and asymmetry in SN

middle third of the posterior surface of leg. The available literature regarding the description of the sural nerve and its formation is controversial.

According to the studies of Coert and Dellon, Williams DD, Hollinshead, and Uluttku et al., [5,11–13], the typical sural nerve is formed by the union of MSCN with the PCN, branch of CPN. On the other hand Bannister et al., reported that the sural nerve is a branch of tibial nerve in the popliteal fossa and is usually joined by a peroneal communicating nerve arising from CPN [3]. They considered the MSCN itself as Sural nerve.

Ortiguela et al., coined the term ‘Sural nerve Complex’ to the nerve that consisted of 4 named components, the MSCN, LSCN, PCN and SN. He found that the sural nerve was formed by the union of the MSCN and the PCN in 80% of specimens and the sural nerve represented the continuation of the MSCN in 20% of cases [1]. The sural nerve is formed by the communication of MSCN with PCN at various levels [9]. In the present study this typical sural nerve is considered as Type A. Williams DD and Huelke’ DF have shown that sural nerve is formed by the union of the MSCN and the PCN in 4 out of 5 cases. The data from this report also indicated that the sural nerve is quite constant. The union between the PCN and the MSCN was seen in 159 specimens (80.3%) [9, 11]. In the present study MSCN communicated with the PCN to form the sural nerve in 36 out of 50 cases. The relative contributions of the MSCN and the PCN to the sural nerve was reported by Kim CH et al., as MSCN was the main contributor to the SN and in 32.9% of subjects PCN was the main contributor [14].

Clemente et al., described that the sural nerve (short saphenous nerve) is formed by the junction of the larger branch, the MSCN (from tibial), and the communicating ramus of LSCN from CPN [10]. Mahakkanukrauh P et al., and Pyun SB et al., have told that the formation of sural nerve was by the union of MSCN and LSCN in 67.1% and 76.9% of cases respectively [15,16].

Huelke DF et al., summarized the formation of the SN as more complex and mentioned that the nerve was formed by 2 components; one from tibial, the other from the common peroneal nerve in 80.7% of cases. Huelke DF has mentioned 3 types of SN formation. Information on the distribution of the cutaneous nerve in anthropoids indicates that the sural nerve is always of tibial anastomotic type. In man the formation of SN, alone by a branch of the common peroneal nerve was seen rarely in 0.3% cases [17]. In the present study, distribution of sural nerve is most commonly of Type A (72%) anastomotic form that is by the 2 component branches, one from tibial and the other from common peroneal nerve. Type B was seen in 28% of cases. Type C was not observed in any of the specimen [Table/Fig-4].

Type of formation of sural nerve	Right		Left		Combined	
	Huelke DF	Present Study	Huelke DF	Present Study	Huelke DF	Present Study
A. Anastomotic	146 (80.7%)	18 (36%)	138 (80.7%)	18 (36%)	284 (80.7%)	36 (72%)
B. Tibial anastomotic	35 (19.7%)	7 (14%)	32 (18.7%)	7 (14%)	67 (19%)	14 (28%)
C. Peroneal non-anastomotic	0	0	1 (0.6%)	0	1 (0.3%)	0

[Table/Fig-4]: Comparison of type of formation of SN with huelke df [17] study

In study done by Huelke et al., out of 3 Types of sural nerve, in Type A the site of union of the MSCN and the PCN was extremely variable [17]. This union may take place anywhere between the popliteal fossa and the lateral malleolus. While recording the observations, each leg was divided into 4 regions. The popliteal fossa was designated as region 1; the limb distal to the fossa was divided into 3 equal parts-the second quarter, the third quarter, and the fourth quarter of the leg. The data obtained from the

previous studies indicated that 3rd quarter of the leg was the most constant site for the formation of sural nerve [17] [Table/Fig-5]. In present study, the site of union of MSCN with PCN (Type A) was more in lower 3rd of leg (58.3%). Similar observations were made by Mahakkanukrauh P et al., [15].

		Huelke (American)	P’an (Chinese)	Mahakkanukrauh P et al.,	Present study
1	Upper quarter of leg (popliteal fossa)	24.3%	6.9%	5.9%	2.8%
2	Second quarter of leg	16.9%	10.7%	----	5.6%
3	Third quarter of leg	36.6%	51.5%	1.9%	33.3%
4	Fourth quarter of leg	22.2%	30.9%	67.4%	58.3%
5	At or just below the ankle	-----	-----	25.5%	-----

[Table/Fig-5]: Analysis of site of union of sural nerve (Type A)

In a study done by Uluutku et al.,, the level of formation of sural nerve was more in middle 3rd in both sexes. The incidence of formation in lower 3rd was more in females [13]. Shanker N et al., had found that the site of union was more in lower 2/3rd of the leg (95%) and 5% in upper 1/3rd of leg. In males the commonest site of union was the middle thirds, while in females it was the lower one thirds of the leg [18]. In present study, formation of sural nerve was more in lower 3rd of leg in both males and females and in middle 3rd the incidence of formation of sural nerve was more in males. SN entrapment was seen in one specimen. This abnormal course can produce pain upon contraction of the gastrocnemius muscle or altered sensation over the area of its distribution [19]. Many studies have reported SN entrapment [19–22]. Pain associated with SN entrapment in athletes and in scar tissue after the injury to gastrocnemius has been reported [23, 24].

The present study showed a wide range of difference in the length of the sural nerve from 2 cm to 32 cm. In males it was measuring between 7-32 cm on right and 8-26 cm on left and in females it was measuring 8-32 cm on right and 10-32 cm on left. The average length of sural nerve in different studies was as follows: Ortiguela ME et al., -11 to 20 cm; Mahakkanukrauh P et al., 6 to 30 cm; and in Present study - 2 to 32 cm.

Observations on symmetry in the formation of the sural nerve by different authors are presented in [Table/Fig-6]. The symmetrical

	Huelke (American) 150 bodies	P’an (Chinese) 143	Mogi (Japanese) 90	Ssokolow (Russian) 250	Present Study 25
Symmetry	82.7%	83.9%	82.2%	78.8%	60%
Asymmetry	17.3%	16.1%	17.8%	21.2%	40%

[Table/Fig-6]: Type of distribution of sural nerve in other studies [15]

group had the same type of formation in both legs, while the asymmetrical group had the anastomotic Type (A) in one leg and a non anastomotic Type (B or C) in the other leg. There was no difference in symmetrical and asymmetrical distribution of SN between male and female (p=1.000). Huelke observed that among 150 bodies, 124 nerve patterns were symmetrical and 26 were asymmetrical. The American, Chinese, Japanese and Russian groups had practically the same percentage of symmetrical and asymmetrical distribution [17]. In the present study, conducted on South Indian cadavers, it was observed that the symmetrical type of distribution (60%) was less when compared to the other studies. This could be probably due to the small sample size and study group was from Indian population. Similar results were observed in a fetal study on anatomical variations of sural nerve by Shankar N et al., [18]. However, results of the Mahakkanukrauh P et al., on

the bilateral symmetry in the sural nerve formation has revealed in 19.7% and asymmetry in 80.35% of the cadavers. Authors have explained that bilateral asymmetry in the pattern of sural nerve formation is a rule rather than the exception, occurring in about 80% of cadavers [15].

Sural nerve is widely used for both diagnostic (biopsy and nerve conduction velocity studies) and therapeutic purposes(nerve grafting) [11,23,25,26] the consistent location of the sural nerve, 1-1.5 cm behind the posterior border of lateral malleolus provides a precise surgical approach and efficient electrode placement for sensory conduction studies [15]. Sural nerve conduction studies are done in focal neuropathies to know the conduction velocity, action potential and amplitude. It is also considered in diagnosis of focal neuropathies, compressive lesions, traumatic nerve lesions and diffuse polyneuropathic conditions. It can be used as an aid in diagnosing neuromuscular junction disorders, and also to know their prognosis by using repetitive nerve stimulation [16, 17]. Sural nerve biopsy is a valuable method for establishing the cause of peripheral neuropathies and also employed in peripheral nerve disorders. It is useful in establishing the diagnosis of certain neuropathies like leprosy, vasculitic neuropathy, amyloid neuropathy, sarcoid neuropathy and chronic inflammatory demyelinating polyradiculoneuropathy [6].

CONCLUSION

Knowledge of the variability of the peripheral nerve distribution allows better insight into the diagnosis of compression neuropathies of the SN due to post- traumatic scarring or extrinsic compression, the evaluation of nerve conduction studies, and for determination of the biopsy sites to help diagnostic entities.

REFERENCES

- [1] Ortiguera ME, Wood MB, Cahill DR. Anatomy of the sural nerve complex. *J Hand Surg.* 1987; 12(6): 1119-23.
- [2] Bergman RA, Thompson SN, Affi AK, Saadeh FA. editors. Compendium of human anatomic variation. Maryland (USA): *Urban and Schwarzenberg Baltimore.* 1988. p 146-47.
- [3] Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE, Ferguson MWJ, editors. In: Gray's Anatomy: The anatomical basis of medicine and surgery. 38th ed. Edinburgh: *Churchill Livingstone.* 1995. p.1145-46.
- [4] Pyun SB, Kwon HK. The effect of anatomical variation of the sural nerve on nerve conduction studies. *Am J Phys Med Rehabil.* 2008; 87(6): 438-42.
- [5] Coert HJ, Dellon AL. Clinical implication of the surgical anatomy of the sural nerve. *Plast Reconstr Surg.* 1994 Nov; 94(6): 850-55.
- [6] Moore KL, Agur AMR, editors. Essential clinical anatomy. 3rd ed. *Baltimore: Williams and Wilkins.* 2007. p. 429.
- [7] Huene DB, Bunnell WP, Linda Loma, California. Operative Anatomy of Nerves Encountered in the lateral Approach to the distal part of the Fibula. *The Journal of Bone and Joint surgery.* 1995; 77(7): 1021-24.
- [8] Webb J, Moorjani N, and Radford M. Anatomy of the sural nerve and its relation to the Achilles tendon. *Foot and Ankle International.* 2000; 21(6): 475-77.
- [9] Huelke DF. The Origin of the Peroneal Communicating Nerve in Adult Man. *Anat Rec.* 1958; 132: 81-92.
- [10] Gray H, The spinal nerves In: Clemente, editor: Anatomy of Human body 30th ed. *Philadelphia Leo and Febiger.* 1985. p. 1238-41.
- [11] Williams DD. A study of human fibular communicating nerve. *Anat Rec.* 1954; 120: 533-43.
- [12] Hollinshead HW. The Back and Limbs. In: Anatomy for Surgeons; Vol 3. *New York: Harper & Brothers.* 1958. p. 766-70.
- [13] Uluutku H, Can MA, Kurtoglu Z. Formation and location of the sural nerve in the newborn. *Surg Radiol Anat.* 2000; 22: 97-100.
- [14] Kim CH, Jung HY, Kim MO and Lee CJ. The relative contributions of the medial sural and peroneal communicating nerves to the sural nerve. *Yonsei Med J.* 2006; 47: 415-22.
- [15] Mahakkanukraha P, Chomsung R. Anatomical variations of the sural nerve. *Clin Anat.* 2002 Jun; 15(4): 263-66.
- [16] Ikiz AZA, Ucerler H, Bilge O. The anatomic features of the sural nerve with an emphasis on its clinical importance. *Foot Ankle Int.* 2005; 26(7): 560-67.
- [17] Huelke DF. A study of the formation of the sural nerve in adult man. *Am. J. Phys. Anthropol.* 1957; 15: 137- 45.
- [18] Shankar N, Selvam RP, Dhanpal N, Reddy R, Alapati A. Anatomical variations of the sural nerve in the leg: A fetal study. *Neurol India.* 2010; 58: 24-28.
- [19] Fabre T, Montero C, Gaujard E, Gervais- Dellion F, Durandeaue A. Chronic calf pain in athletes due to sural nerve entrapment. A report of 18cases. *AMJ Sports med.* 2000; 28: 679-82.
- [20] Shankar N and Veerumani R. An unusual origin and intramuscular course of the sural nerve- A case report. *Neuroanatomy.* 2008; 7: 79-82.
- [21] Pringle RM, Protheroe K, Mukherjee SK. Entrapment neuropathy of the sural nerve. *J Bone joint Surg Br.* 1974; 56B: 465-68.
- [22] Nayak SB. Sural nerve and short saphenous vein entrapment- A case report. *Indian J Plastic Surg.* 2005; 38(2): 171-72.
- [23] George BM, Nayak S. Sural nerve entrapment in gastronemius muscle- a case report. *Neuroanatomy.* 2007; 6: 41-42.
- [24] Toy BJ. Conservative treatment of bilateral sural nerve entrapment in an ice hockey player; *Journal of Athletic Training.* 1996; 31(1): 68-70.
- [25] Sankar DK, Bhanu SP, Susan PJ. Variant formation of sural nerve and its distribution at the dorsum of the foot. *International Journal of anatomical variations.* 2008; 1: 33-34.
- [26] KimYT, Moon JS, Kim JK. Anatomical investigation of sural nerve and its contributing nerves. *J Korean Acad Rehabil Med.* 2003; 27(5): 723-26.

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