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Original Article

Anatomical variations of the formation of human sural nerve in stillborns

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ABSTRACT

Introduction: The sural nerve (SN) is formed by the union of the medial and lateral sural cutaneous nerves (MSCN, LSCN) of the leg that originate from the tibial and common peroneal nerves. Sural nerve is used for various reasons in surgical operations. The sural nerve is universally recognized by surgeons as a site for harvesting an autologous nerve graft The aim of this study was to describe the course, variations, morphometric analysis and some clinically significant relations of the human sural nerve in stillborns.
Methods: The study was carried out on 18 Turkish stillborns, 12 males and 6 females. The formation of sural nevre was classified into three main groups. The site of formation of the sural nerve was observed and the length of the sural nerve components were measured.
Results: Three types of SN formation were observed. Type A (anastomotic type) was seen in 33 of the observed 36 legs (92%). The site of formation of the SN by union of the MSCN and LSCN was 30% (10/33). In males, the mean length of MSCN was 24.59 ± 14.84 mm and 27.45 ± 23.30 mm in females.
Discussion: This study was performed to ensure an anatomical and morphometrical description of the sural nerve and its components in 18 embalmed stillborns. Due to its great importance in neurosurgery and plastic surgery, the formation type, course and formation level of the sural nerve have been studied on different races and age groups since the beginning of the last century.

1. Introduction

The sural nerve (SN) is a sensory nerve supplying the skin of the lateral and posterior part of the inferior third of the leg and lateral side of the foot.[1] Generally it is formed by the union of the medial sural cutaneous nerve(MSCN), a branch of the tibial nerve(TN), and the lateral sural cutaneous nerve(LSCN), a branch of common peroneal nerve(CPN).[2] Since the SN is used as a graft for many peripheral nerve lesions, anatomic study of this nerve in cadavers is important to reveal such information as the formation type and site of the nerve and its relationship to surrounding structures.[3]

The nomeclature applied to the LSCN contribution is confusing.[2] Some authors term this branch the peroneal communicating branch(PCB) of CPN[4] or communicating ramus of LSCN.[5,6,7] Coert and Dellon[8] and Mahakkarauh and Chomsung[2] term this branch LSCN. In the present study we followed them and called it LSCN. The components of sural nerve(MSCN, LSCN) communicate at a variable level of leg. This union may occur in the upper third of the leg, middle third of the leg or the lower third of the leg.[7] Some authors classified the union site into four groups; upper, second, third and fourth quarter of the leg.[5,6,9]

Sural nerve is used for various reasons in surgical operations. Foremost among these reasons are peripheral nerve surgery. Because SN is a pure sensory nerve, provides enough grafting and causes no problems in its absence; it is the most frequently chosen graft source in peripheral nerve injuries.[10] Also, sural nerve biopsy is usually preferred for common peripheral nerve diseases.[11,12]

Sural nerve transmits sensory signals from the lateral dorsum of the foot and 5th toe to the brain.[12,13] Tissue loss might be seen in this region due to local traumas and diabetes mellitus. Especially, additional complications may occur after surgical interventions due to systemic problems in patients with diabetes mellitus. Regional anesthesia is preferred in these cases because general anesthesia might increase this risk. Thus, sural nerve block during surgical interventions in the location of SN is a proper preference that will increase patient comfort and lower the possibility of systemic complications and can be easily performed by the surgeon. Sural nerve block can be achieved by the injection of

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Table 1
Distribution of symmetry and asymmetry in Sural Nerve.

Symmetry / Asymmetry in Sural Nerve	% (n)
Symmetry	**83% (15/18)**
Asymmetry	**17% (3/18)**
Total	**100% (18/18)**

Table 2
Formation Type of SN. SN: Sural Nerve.

Formation Type of Sural Nerve	% (n)
Type A SN (Anastomotic Type)	**92% (33/36)**
Type B SN (Tibial Non-anastomotic Type)	**8% (3/36)**
Type C SN (Peroneal Non-anastomotic Type)	**0%(0/36)**
Total	**100% (36/36)**

Table 3
Forming Location of Sural Nerve.

Forming Location of Sural Nerve	% (n)
1st Ouarter of Leg (Popliteal Fossa)	**0% (0/36)**
2nd Ouarter of Leg	**30% (10/33)**
3rd Ouarter of Leg	**70% (23/36)**
4th Ouarter of Leg	**0% (0/36)**
Total	**100% (36/36)**

5–7 ml %2 lidocaine solution infiltration in the area between Achilles tendon and lateral malleolus.[14] Cutaneous nerve blocks of the lower extremity are useful anesthetic techniques that can be used as a sole anesthetic technique for minor surgical procedures. More commonly, these blocks are used as an adjunct to the major conduction blocks of the lower extremity. These blocks are superficial, require minimal equipment, are relatively simple to accomplish and learn, and should be in the armamentarium of every practitioner.[15]

Surgeons and anesthetists should have the knowledge of sural nerve anatomy because of the reasons mentioned above.The aim of this study was to describe the course, variations, morphometric analysis and some clinically significant relations of the human sural nerve in stillborns.

2. Material and methods

The study was carried out on 18 Turkish stillborns, 12 males and 6 females. They were preserved in %5 formalin. Each specimen was dissected by removal of the skin and the fascia of the back of the thigh, popliteal fossa, leg and dorsum of the foot.

The formation of SN was classified into three main groups. The pattern of formation of the SN has been broadly divided into three types A, B and C by Huelke.[6] Type A is called the anostomotic type and receives a contribution from the TN, termed the MSCN and a contribution from the CPN called the LSCN. Type B and C are non-

Table 4
The Length of Sural Nerve Components. MSCN: Medial Sural Cutaneous Nerve, LSCN: Lateral Sural Cutaneous Nerve.

Branch of Sural Nerve	Male	Female	p
MSCN	**24.59 ± 14.84 mm**	**27.45 ± 23.30 mm**	**(p = 0.880, p > 0.05)**
LSCN	**27.04 ± 16.33 mm**	**28.82 ± 24.46 mm**	**(P = 0.614, p > 0.05)**

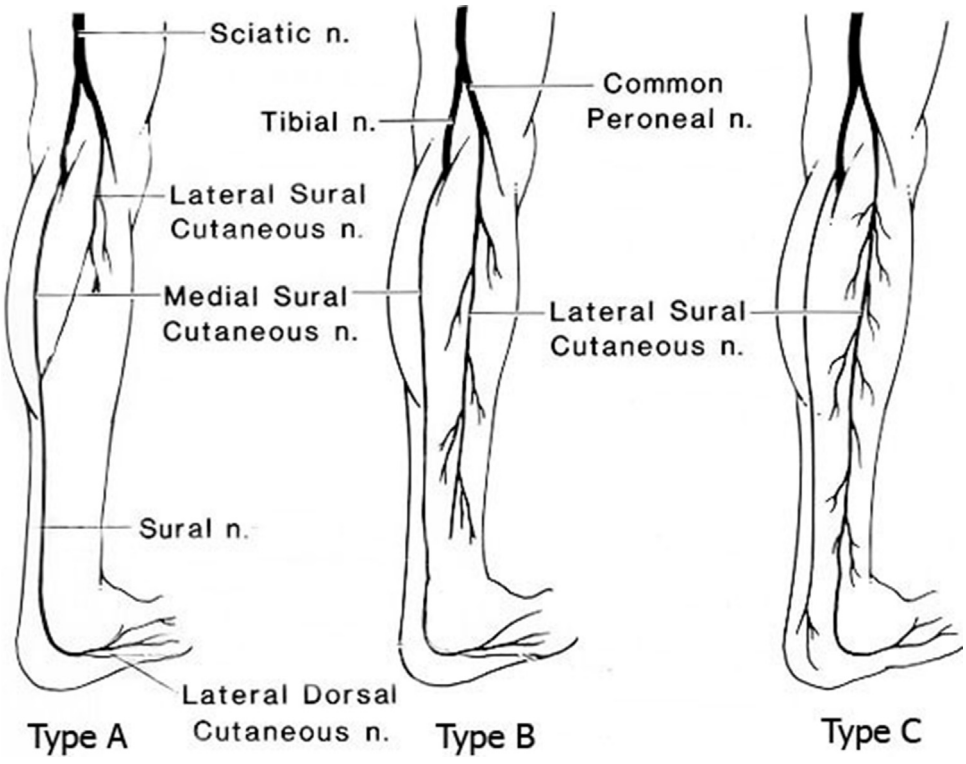

Fig. 1. The types of the formation of the sural nerve (SN). Type A: Anastomotic type, Type B: Tibial non-anastomotic type, Type C: peroneal non-anastomotic type. (Modified from Huelke[6]).

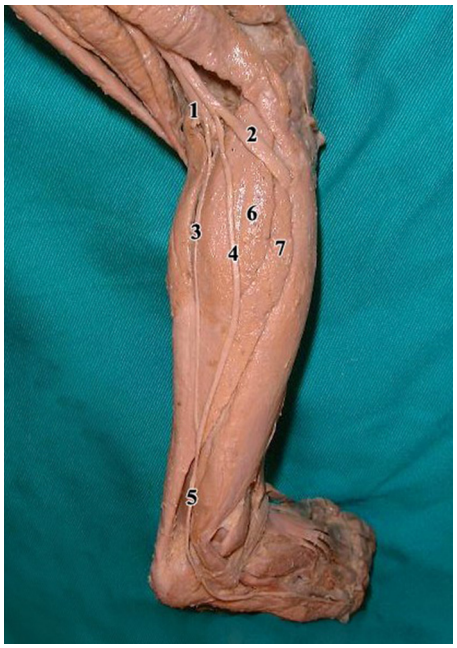

Fig. 2. Type A formation of the sural nerve (SN) in the third quarter of the leg: 1- Tibial nerve (TN), 2- Common peroneal nerve (CPN), 3- Medial sural cutaneous nerve (MSCN), 4- Lateral sural cutaneous nerve (LSCN), 5- Sural nerve (SN), 6- Gastrocnemius muscle, 7- Soleus muscle.

anostomotic pattern of formation. Type B is tibial non-anostomotic type, contribution is entirely by the MSCN. In type C, peroneal non-anastomotic type, the contribution is entirely by the LSCN.

The site of formation of the SN of type A was observed at four locations; upper, second, third and fourth quarters of the leg. The course of the MSCN and LSCN were analysed with the stereomicroscope 4×0.63 to 4×4 magnification. The length of the MSCN and LSCN were measured with digital sliding caliper 200 mm, 0,01 mm accuracy, from the point of the origin to the union.

Statistical analyses were made by using Excel and SPSS (SPSS Inc., Chicago, IL, USA) system for Windows, version 21.0. All results were expressed as mean ± S.D. Normality tests are used to determine Shapiro-Wilk and Kolmogrov-Smirnov ($p < 0.05$). Comparisons between different groups were made using Mann- Whitney U test. In all cases, $p < 0.05$ was considered to be significant.

Fig. 3. Type B formation of the sural nerve (SN):1- Tibial nerve (TN), 2- Common peroneal nerve (CPN), 3- Sural nerve (SN) is formed by the medial sural cutaneous nerve (MSCN), 4- Lateral sural cutaneous nerve (LSCN).

3. Results

The sural nerve complex was observed in 36 formalin fixed lower limbs in 18 stillborn cadavers. The results were summarized in Tables 1–4.

4. Discussion

This study was performed to ensure an anatomical and morphometrical description of the SN and its components in 18 embalmed stillborns. The results revealed bilateral symmetry in the pattern of SN formation in 83%(15/18) and asymmetry in 17% (3/18) of the cadavers (Table 1). Type A SN (anastomotic type) was observed in 33 out of 36 legs (92%) (Figs.1, 2, and 4) (Table 2). Type B SN (tibial non- anastomotic type) was observed in 3 out of 36 legs (8%) (Figs. 1–3) (Table 2). Type C SN (peroneal non-anastomotic) was not found in the present study (Fig. 1) (Table 2). The site of formation of the SN by union of the MSCN and LSCN was 30% (10/33) in the second quarter of the leg (Fig. 4), 70% (23/33) in the third quarter of the leg (Fig. 2) (Table 3). The union of the SN components was not seen in the first and fourth quarters of the leg

Fig. 4. Type A formation of the sural nerve (SN) in the second quarter of the leg: 1- Tibial nerve (TN), 2- Common peroneal nerve (CPN), 3-Sciatic nerve, 4-Medial sural cutaneous nerve (MSCN), 5- Lateral sural cutaneous nerve (LSCN), 6- Sural nerve (SN), 7- Gastrocnemius muscle.

Table 5
Type of Distribution of Sural Nerve in Other Studies.

	Mahakkarauh	Huelke	P'an	Shankar	Present study
Symmmetry	**19.7%**	**82.7%**	**83.9%**	**60.8%**	**83.3%**
Asymmetry	**80.3%**	**17.3%**	**16.1%**	**39.2%**	**16.7%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**

(Table 3). In males, the mean length of MSCN was 24.59 ± 14.84 mm and 27.45 ± 23.30 mm in females ($p = 0.880$, $p > 0.05$) (Table 4). The mean length of LSCN was 27.04 ± 16.33 mm in males and 28.82 ± 24.46 mm in females (Table 2).There was no significant difference between the sexes ($P = 0.614$, $p > 0.05$).

Due to its great importance in neurosurgery and plastic surgery, the formation type, course and formation level of the SN have been studied on different races and age groups since the beginning of the last century.

Mahakkarauh and Chomsung[2] stated that bilateral asymmetry in the pattern of SN formation is the rule rather than the exception, occuring in about 80% of cadavers. But most of the studies on the formation of the SN have shown that bilateral symmetry or asymmetry is not a rule[6,9,15] (Table 5). These varieties may be due to racial differences or the number of specimen.

P'an was the first investigator to classify the SN into three main groups; anastomotic type (type A), tibial non-anastomotic type (type B) and peroneal non-anastomotic (type C).[16] P'an[9] found that the most frequent type was type A (Table 6). It was occured in more than four-fifth of all cases. Also P'an[9] made a racial comparison between Chinese, Japanese and certain European races. The anastomotic type was found in 40.2% by Kosinsky, 51% by Catania and 52.6% by Sskolow in European races.[16] In respect of these datas, P'an[9] stated that there exists a marked contrast between the datas of Oriental and European races. But recent studies in European races showed a higher incidance of type A SN. It was found in 72.5% by Ugronovic et al,[17] 83.8% by Mestagh et al[5] and 63% by Riedl and Frey[18] in certain European races. Contrary to P'an, the recent studies in Oriental races showed a lower incidence of type A SN. It was found in 67.1% by Mahakkarauh and Chomsung,[2] 76.9% by Pyun and Kwon,[19] 60% by Seema,[20] 37.3% by Shankar et al[16] and 72% by Kavyashree el al.[21]

Williams[22] and Huelke[6] were found the type A SN in 83.7% and 80.7% respectively in American cadavers. Huelke[6] was pointed to conflicting results in American cadavers. Because the data of Williams[22] was agreed closely with those of his study but Bardeen's[23] datas were differed considerably. Bardeen[23] indicated that type A SN formation in only 59.2% of cases.

In Turkey, the results of the studies on the formation of SN were almost variable. Uluutku[7] found the type A SN in 82.5% out of 40 foetal lower limbs. Albay et al[24] found this type in 71% out of 100 foetal lower limbs, Aktan Ikiz et al[25] found this frequency to be 60% in 30 lower limbs of cadavers. The major difference in the present study as compared to previous studies is the highest incidence of type A SN (Table 6).

Type B SN was observed in 8.4% in this study. It was the lowest incidence of type B SN after Kim's[26] study. Kim[26] found this ratio in 6.4% in Korea. The above mentioned investigators found this ratio to be 13,3% by P'an,[9] 15.9% by Williams,[22] 19% by Huelke,[6] 39.5% by Bardeen,[23] 26% by Ugronovic et al,[17] 12.2% by Mestagh et al,[5] 37% by Riedl and Frey[18] and 32.2% by Mahakkarauh and Chomsung.[2] Shankar,[16] Seema[20] and Kavyashree[21] were found this ratio to be 37.3%, 39% and 28% respectively in India. This type was reported in 16.7 by Aktan Ikiz et al,[25] 12.5% by Uluutku[7] and 20% by Albay et al.[24] Shankar [16] was stated that type B SN was found 53.8% by Kosinsky, 35% by Catania, 43.8% by Ssokolow.

In none of our cases was the LSCN was found in the SN position (Type C) as described by Mestdagh et al[5], Ugrenovic et al[17] or in the PCB as described by Williams,[22] P'an[9] and Kavyashree.[21] Type C SN varies from 0% to 14% in various studies conducted throughout the world. These differences may be due to genetic variations in different races.[16]

In type A SN, the site of the union of the MSCN and the LSCN is very variable. It may take place as high as the level of knee joint and as low as the level of ankle joint. The formation level was in four equal regions. Some authors agreed that in 33.3%–67.4% of cases, the SN formation occurs at the third quarter of the leg.[6,9,21] We found this formation in 69.7% of the 36 lower limbs, followed by the second quarter of the leg with 30.3%.

Also the length of the MSCN and LSCN were measured and compared between the genders. The mean length of the MSCN was found to be 24.59 ± 14.84 mm in males and 27.45 ± 23.30 mm in females. The mean length of LSCN was found to be 27.04 ± 16.33 mm in males and 28.82 ± 24.46 mm in females. Albay et al[24] found the mean length of the MSCN and LSCN 32.96 m m and 31.22 m m respectively in 35 foetal cadavers.

Table 6
Formation of Sural Nerve. SN: Sural Nerve.

Author	n	Type A SN (%)	Type B SN (%)	Type C SN (%)
Bardeen (USA–1906)	**76**	**59.2**	**39.5**	**1.3**
Kosinsky (Poland–1924)	**234**	**40.2**	**53.8**	**6**
Catania (Italy–1924)	**94**	**51**	**35**	**14**
Sskolow (Russia–1933)	**500**	**52.6**	**43.8**	**3.6**
P'an (China–1939)	**286**	**81.5**	**13.3**	**5.2**
Williams (USA–1954)	**257**	**83.7**	**15.9**	**0.4**
Huelke (USA–1958)	**352**	**80.7**	**19**	**0.3**
Ortiguela et al (1987)	**20**	**80**	**20**	–
Coert and Dellon (1994)	**50**	**96**	**4**	–
Uluutku (Turkey–2000)	**40**	**82.5**	**12.5**	–
Mestdagh (France–2001)	**74**	**83.8**	**12.2**	**4.1**
Mahakkarauh (Thailand–2002)	**152**	**67.8**	**32.2**	–
Aktan Ikiz (Turkey–2005)	**60**	**60**	**16.7**	–
Ugrenovic (Serbia–2005)	**200**	**72.5**	**26**	**1.5**
Kim (Korea–2006)	**94**	**93.6**	**6.4**	–
Pyun and Kwon (2008)	**52**	**76.9**	**15.4**	–
Shankar (2009)	**102**	**37.3**	**26.5**	**22.5**
Albay et al (2012)	**200**	**71**	**20**	–
Kavyashree et al, 2013	**50**	**72**	**28**	–
Seema (2013)	**200**	**60**	**39**	**1**
Present study	**36**	**92**	**8**	–

5. Conclusion

Sural nerve use is preferred by surgeons in many surgical interventions commonly. The variation of SN is an important surgical issue when it is used as an autograft for peripheral nerve reconstruction. Surgeons should be aware of the variations in the SN formation to avoid injury to the nerve during surgical procedures. As a result, adequate level of knowledge of SN anatomy is required to minimize the possible problems that may occur and increase success rate in interventions of SN.

Conflict of interest

None.

References

1. Moore KL, Dalley AF. *Clinically oriented anatomy*. 4th edition Philadelphia: Lippincott Williams & Wilkins; 1999.
2. Mahakkanukrauh P, Chomsung R. Anatomical variations of the sural nerve. *Clin Anat*. 2002;15:263–266.
3. De Moura W, Gilbert A. Surgical anatomy of the sural nerve. *J Reconstr Microsurg*. 1984;1(1):31–39.
4. Ortiguela ME, Wood MB, Cahill DR. Anatomy of the sural nerve complex. *J Hand Surg Am*. 1987;12:1119–1123.
5. Mestdagh H, Drizenko A, Maynou C, et al. Origin and make up of the human sural nerve. *Surg Radiol Anat*. 2001;23:307–312.
6. Huelke DF. A study of the formation of the sural nerve in adult man. *Am J Phys Anthropol*. 1957;15:137–145.
7. Uluutku H, Can MA, Kurtoglu Z. Formation and location of the sural nerve in the newborn. *Surg Radiol Anat*. 2000;22:97–100.
8. Coert HJ, Dellon AL. Clinical implication of the surgical anatomy of the sural nerve. *Plast Reconstr Surg*. 1994;94(November (6)):850–855.
9. P'an MT. Formation of the sural nerve in the Chinese. *Am J Phys Anthrop*. 1939;25:311–321.
10. Millesi H. Techniques for nerve grafting. *Hand Clin*. 2000;16(1):73–91.
11. Kanda T. Usefulness of sural nerve biopsy in the genomic era. *Neuropathology*. 2009;29(4):502–508.
12. Eid EM, Hegazy AM. Anatomical variations of the human sural nerve and its role in clinical and surgical procedures. *Clin Anat*. 2011;24(2):237–245.
13. Malsawmzuali JH, Sylvan DA, Mamatha H, et al. The variations in the distribution of sural nerve on the dorsum of the foot. *J Anat Soc India*. 2015;64:S45.
14. Myerson MS, Ruland CM, Allon SM. Regional anesthesia for foot and ankle surgery. *Foot Ankle*. 1992;13(5):282–288.
15. Visan A, Bartoc C, Hadzic A, et al. Cutaneous nerve blocks of the lower extremity. *Tech Reg Anesth Pain Manag*. 2003;7(1):26–31.
16. Shankar N, Selvam RP, Dhanpal N, et al. Anatomical variations of the sural nerve in the leg: a fetal study. *Neurol India*. 2010;58:24–28.
17. Ugrenovic S, Vasovic L, Jovanovic I, et al. Peculiarities of the sural nerve complex morphologic types in human fetuses. *Surg Radiol Anat*. 2005;27:25–29.
18. Riedl O, Frey M. Anatomy of the sural nerve: a cadaver study and literature review. *Plast Reconstr Surg*. 2013;131(April (4)):802–810.
19. Pyun SB, Kwon HK. The effect of anatomical variation of the sural nerve on nerve conduction studies. *Am J Phys Med Rehabil*. 2008;87:438–442.
20. Seema SR. Study of sural nerve complex in human cadaver. *ISRN Anat*. 2013;127 article ID 827276.
21. Kavyashree AN, Lakshmi, PS, Asha KR, et al. Anatomical variations in formation sural nerve in adult Indian cadavers. *J Clin Diagn Res*. 2013;7(September (9)):1838–1841.
22. Williams DD. A study of human fibular communicating nerve. *Anat Rec*. 1954;120:533–543.
23. Bardeen CR. Development and variation of the nerves and the musculature of the inferior extremity and of the neighboring regions of the trunk in man. *Am J Anat*. 1906;6:259–391.
24. Albay S, Sakallı B, Kastamoni Y, et al. Formation of the sural nerve in foetal cadavers. *Folia Morphol (Warsz)*. 2012;71(November (4)):221–227.
25. Aktan IZA, Uçerler H, Bilge O. The anatomic features of the sural nerve with an emphasis on its clinical importance. *Foot Ankle Int*. 2005;26:560–567.
26. Kim CH, Jung HY, Kim MO, et al. The relative contributions of the medial sural and peroneal communicating nerves to the sural nerve. *Yonsei Med J*. 2006;47:415–422.