e-ISSN: 0975-9506, p-ISSN:2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2025; 16(1); 56-68

Original Research Article

# Anatomical Variations of Sural Nerve and its Clinical Implications

**Jayasree S[1], Bharanidharan M[2], Ranjith Babu R[3], Priyadarshini D[4]**

[1]Tutor, Department of Anatomy, Government Medical College, Ramanathapuram, Tamilnadu, India
[2]Assistant Professor, Department of Neurosurgery, Madurai Medical College, Madurai, Tamilnadu, India
[3]Assistant Professor, Department of Vascular surgery, KAPV Government Medical College, Trichy, Tamilnadu, India
[4]Assistant Professor, Department of Physiology, Government Medical College, Pudukkottai, Tamilnadu, India

**Received: 25-09-2024 / Revised: 23-10-2024 / Accepted: 26-11-2024**
**Corresponding Author: Dr. Priyadarshini D.**
**Conflict of interest: Nil**

**Abstract:**

**Introduction and Background:** Sural nerve can be used for diagnostic purposes like nerve conduction velocity study and for nerve biopsy for various neuromuscular disorders. It is also widely used for electrophysiological studies. Knowledge about the course of the sural nerve and variations in its course would be hugely helpful in carrying out the aforementioned studies. This knowledge will also be helpful while performing procedures like autologous peripheral nerve grafting and nerve biopsy.

**Aims and Objectives:** The aim of this study is to study the variations of sural nerve formation, its course in the leg and its relations with Tendo-Calcaneus, short saphenous vein and lateral malleolus for its clinical application.

**Methodology:** This was a descriptive study done in the Institute of Anatomy, Madras Medical College, Chennai, Tamilnadu, India. The study was conducted by following the guidelines of Cunningham's manual. This study included 50 lower limb specimens from 25 cadavers fixed in 10% formalin. Both male and female 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 and Vernier's calliper.

**Results:** The mean length of leg measured from flexor crease to heel in our study was 43.96 cm. The most common type of sural nerve formation is Type-A. In males, Type-A sural nerve formation was most commonly located at lower 1/3rd of leg with 63.7% specimens (n=7) on right side. In females, Type-A sural nerve formation was most commonly located at lower 1/3rd of leg with 71.4% specimens (n=5) on right side and 75% specimens (n=6) on left side. The symmetricity of sural nerve formation between right and left lower limbs was noted in 11 male cadavers (78.6%) and 6 female cadavers (n=54.5%). Sural nerve formation was asymmetric in 3 male (21.4%) and 5 female (45.5%) cadavers. Sural nerve pierced deep fascia most commonly at lower 1/3rd of leg as noted in 50% of specimens. The mean distance between the site of sural nerve piercing deep fascia and lower border of lateral malleolus was 18.07 cm. The mean length of sural nerve measured from its formation to lateral malleolus was 31.54 cm. the mean distance between sural nerve and posterior border of lateral malleolus at its midpoint was 0.95 cm. The mean distance between the site of sural nerve crossing lateral border of Tendo-calcaneus and lower border of lateral malleolus was 4.82 cm. The mean distances noted at 5cm reference point was 0.17 cm lateral to Tendo-calcaneus. At 7cm and 10cm reference points, sural nerve was medial to lateral border of Tendo-calcaneus with mean distances -1.5cm and -3.92 cm respectively.

**Keywords:** Sural nerve, Variations in sural nerve course, Clinical implications.



## Introduction

Sural nerve which is also known as Nervus Suralis, is one among the cutaneous nerves that supply the lower limb. It is a branch from tibial nerve in the popliteal fossa, descends between the two heads of the gastrocnemius muscle, and pierces the deep fascia proximally in the posterior surface of the leg. Usually it is joined by the sural communicating nerve (peroneal communicating nerve), which is a branch of common fibular nerve. [1,2] The term "Sural Nerve Complex" was coined by Ortiguela in 1987, which includes medial sural cutaneous nerve, lateral sural cutaneous nerve, peroneal communicating nerve and sural nerve. [3] It then descends lateral to tendo-calcaneus and close to the short saphenous vein to enter the region between lateral malleolus and the calcaneum. It then supplies the posterior and lateral aspect of skin in the distal third of the leg. Then the sural nerve

curves and passes distal to the lateral malleolus along the lateral aspect of foot till the fifth toe and supplies the skin over that region . It communicates with the posterior femoral cutaneous nerve present in the leg, as well as the superficial fibular nerve in the dorsum of the foot.

**Anatomy of Sural Nerve [4]**

Sural nerve is one of the major cutaneous nerves of the lower limb. It is a branch from Tibial nerve (TN) in the popliteal fossa, descends between the two heads of the gastrocnemius muscle, and pierces the deep fascia in the middle third of the posterior surface of the leg. It is usually joined by the peroneal communicating nerve (sural communicating nerve) which is a branch of common peroneal nerve (CPN).

Medial sural cutaneous nerve originates from the tibial nerve in the popliteal fossa. It descends between the two heads of gastrocnemius muscle, deep to deep fascia covering the muscle. It becomes superficial by piercing the deep fascia at the junction of middle and distal thirds of the leg. The nerve lies usually medially sometimes laterally to the short saphenous vein. The nerve joins the peroneal communicating nerve to form sural nerve. When there is no communication between medial sural cutaneous nerve and peroneal communicating nerve, the medial sural cutaneous nerve supplies the lateral surface of the leg and gives off lateral branch to the heel and continues as lateral dorsal cutaneous nerve. Lateral sural cutaneous nerve originates from common peroneal nerve in popliteal fossa; it descends between deep fascia and lateral head of gastrocnemius muscle; at the middle of the calf it pierces the deep fascia to become subcutaneous. Peroneal communicating nerve originates in the popliteal fossa either from lateral sural cutaneous nerve or directly from the common peroneal nerve. The nerve communicates with the medial sural cutaneous nerve to form sural nerve. The sural nerve is a sensory nerve of the lower limb that supplies the lower posterolateral part of the leg and lateral part of the dorsum of the foot. It is generally described as a sensory nerve but may contain motor fibres. The sural nerve is universally recognized by surgeons as a site for harvesting an autologous nerve graft. The nerve is widely used for electrophysiological studies. It continues as the lateral dorsal cutaneous nerve below the lateral malleolus and joins the intermediate dorsal cutaneous nerve on the dorsum of the foot. The terminal branches of the nerve communicate with the other collateral branches of the common tibial and fibular nerve. It comprises of spinal nerve roots from S1 and S2. It acts as a guide to the tibial nerve since it lies superficial to deep fascia below the knee. It is in close approximation with the peroneus brevis tendon. Cutaneous nerves are clearly visible on the dorsum of the foot when examined closely.

**Clinical Significance**

**Sural Nerve Entrapment:** Sural nerve entrapment is most commonly caused by fascial thickening. This usually happens at the site where the nerve becomes superficial to gastronemius called the superficial sural aponeurosis. Patients with sural nerve entrapment typically present with sensory changes in the areas of skin supplied by sural nerve. Sensory changes can be parasthesias, hyperasthesia or dysasthesias in the region of lateral aspect of foot and posterolateral aspect of distal leg. On examination, the area of entrapment may betender on palpation. Differential diagnosis include sciatica, piriformis syndrome and popliteal artery entrapment. Surgical decompression by removing the constricting fascial band is the treatment of choice.

**Materials and Methods**

**Aim of the study:** Sural nerve can be used for diagnostic purposes like nerve conduction velocity study and for nerve biopsy for various neuromuscular disorders.[5,6] It is also widely used for electrophysiological studies.[7,8,9,10]

**Study Design:** This study was a descriptive study and the knowledge obtained had been compared and contrasted with related works available in the literature. The study was conducted over a period of two years from January 2021 to October 2022. The study was conducted at the Institute of Anatomy, Madras Medical College, Chennai, after obtaining proper clearance from the Institutional Ethics Committee.

**Methodology**

The gross dissection was done by following the guidelines of Cunningham's manual. This study included 50 lower limb specimens from 25 cadavers fixed in 10% formalin.

Both male and female cadavers were included in the study. The data was collected by dissection method by using dissection instruments, and the parameters (measurements) were obtained by using measuring tape and Vernier's calliper.

**Exclusion Criteria**

1. Any pathology in the lower limb,
2. Lower limb with gangrene or any crush injury or deformity
3. Amputated lower limb
4. Operated lower limb

**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 small 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.

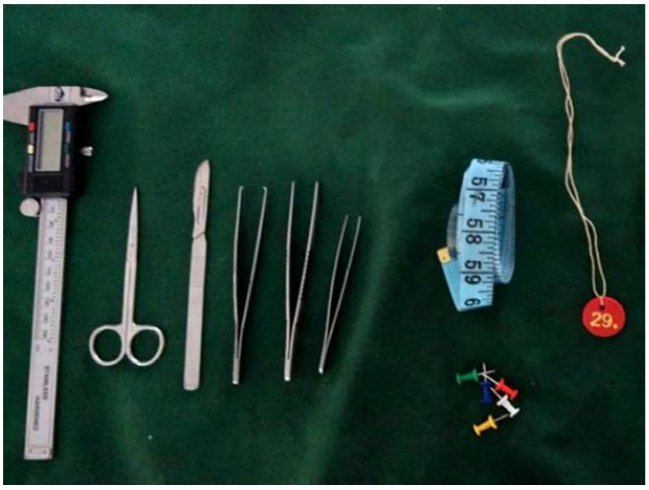

**Figure 1: Materials and instruments used for dissection and observations**

The posterior compartment of the leg was dissected to study the formation and course of the sural nerve. The variations in the course of the nerve and its variation with short saphenous vein and Tendo-Calcaneuswas studied.

**Study Parameters**

**1. Formation of the Sural Nerve**

**Type A:** Medial sural cutaneous nerve joins with peroneal communicating branch of common peroneal nerve and forms sural nerve.

**Type B:** Sural nerve is a continuation of medial sural cutaneous nerve and peroneal communicating nerve is absent.

**Type C:** Sural nerve was formed by continuation of lateral sural cutaneous nerve or peroneal communicating nerve

**2. Site of Formation of Sural Nerve**

Total length of the leg was measured from the flexor crease of popliteal fossa to the calcaneal tuberosity. The leg is divided into upper third, middle third and lower third depending upon the length of the leg. Now the observations were made to find the site of sural nerve formation with respect to upper third or middle third or lower third of the leg.

**3. Symmetry of the Nerve in Both the Limbs**

Any asymmetry of sural nerve formation between both lower limbs of single cadaver was observed.

**4. Site of Piercing Deep Fascia and Becoming Cutaneous**

Total length of the leg was measured from the flexor crease of popliteal fossa to the calcaneal tuberosity. Now the total length of the leg is divided into upper third, middle third and lower third depending upon the length of the leg. In its course sural nerve will piece deep fascia and will become cutaneous. The site of sural nerve piercing deep fascia and becoming cutaneous was observed with respect to upper or middle or lower third of leg. The distance between the site of sural nerve piercing deep fascia and lower border of lateral malleolus was measured.

**5. Length of the Sural Nerve in the Leg**

Length of the sural nerve was measured from the site of formation to the lower border of the lateral malleolus

**6. Relation with Lateral Malleolus**

With the reference point at the centre point of the lateral malleolus, the distance between posterior border of lateral malleolus and sural nerve was measured at the level of centre of lateral malleolus.

**7. Relation with Tendo-Calcaneus**

Sural nerve usually lies lateral to the lateral border of the Tendo-Calcaneus. Markings were made at three reference points at 5cms (point A),7cms (point B) and 10cms (point C) from the heel in the lateral border of the tendon. The distance between the sural nerve and these reference points were measured.

**Results**

**Length of Leg**

**Table 1: Length of Leg**

| | All (N=50) | Males (N=28) | Females (N=22) |
|---|---|---|---|
| Mean | 43.96 | 47.28 | 39.7 |
| Median | 43 | 47.5 | 39 |
| Standard Deviation | 5.17 | 4.22 | 2.47 |
| Minimum | 36 | 40 | 36 |
| Maximum | 54 | 54 | 44 |
| Range | 18 | 14 | 8 |
| Standard Error | 0.73 | 0.79 | 0.52 |

As shown in table-1, the mean length of leg measured from flexor crease to heel in our study was 43.96 cm with standard deviation of 5.17 and ranges from 36 cm to 54 cm. The minimum and maximum length of leg was 40 cm and 54 cm respectively in males, and that in females it was 36 cm and 44 cm respectively. The mean length of leg was 47.28 cm and 39.7 cm respectively in males and females.

**Type of Sural Nerve Formation**

**Table 2: Type of Sural Nerve Formation**

| Type | Frequency | Percentage |
|---|---|---|
| A (MSCN + PCN ) | 37 | 74% |
| B (Continuation of MSCN) | 12 | 24% |
| C (Continuation of LSCN) | 1 | 2% |
| Total | n=50 | |

As shown in table-2, in our study, the most common type of sural nerve formation is Type-A (anastomotic type) wherein medial sural cutaneous nerve joins with peroneal communicating nerve which is a branch from lateral sural cutaneous nerve to form sural nerve. This type was seen in 74% of specimens (n=37). Type-B (non-anastamotic) formation in which medial sural cutaneous nerve continues as sural nerve was seen in 24% of specimens (n=12). Type-C formation (non-anastomotic) in which sural nerve is a continuation of LSCN/PCN was noted in one specimen.

**Type of Sural Nerve Formation in Males**

**Table 3: Type of Sural Nerve Formation in Males**

| Type | Males (N=28) | | | |
|---|---|---|---|---|
| | Right | | Left | |
| | N | % | N | % |
| A (MSCN + PCN) | 11 | 78.6% | 11 | 78.6% |
| B (Continuation of MSCN) | 2 | 14.3% | 3 | 21.4% |
| C (Continuation of LSCN) | 1 | 7.1% | 0 | 0% |
| Total | 14 | 100% | 14 | 100% |

As shown in table-3, in males, out of 28 lower limb specimens, Type-A formation was the most common noted in 78.6% (n=11) of specimens on each side. This was followed by Type-B formation in total 2 specimens (14.3%) on right side and 3 specimens (21.4%) on left side. Type-C formation was noted in one right lower limb specimen.

**Type of Sural Nerve Formation in Females**

**Table 4: Type of Sural Nerve Formation in Females**

| Type | Females (N=22) | | | |
|---|---|---|---|---|
| | Right | | Left | |
| | N | % | N | % |
| A (MSCN + PCN) | 7 | 63.6% | 8 | 72.7% |
| B (Continuation of MSCN ) | 4 | 36.4% | 3 | 27.3% |
| C (Continuation of LSCN) | 0 | 0% | 0 | 0% |
| Total | 11 | 100% | 11 | 100% |

As shown in table-4, in females, out of 22 lower limb specimens, Type-A formation was the most common on both sides noted in 63.6% specimens (n=7) on right side and 72.7% (n=8) specimens on left side. Type-B formation was noted in total 4 specimens (36.4%) on right side and 3 specimens (27.3%) on left side. Type-C formation was not seen in female cadavers in our study.

**Location of Type-A Sural Nerve Formation**

**Table 5: Location of Type-A Sural Nerve Formation In Males**

| Location In Leg | Males | | | |
|---|---|---|---|---|
| | Right | | Left | |
| | N | % | N | % |
| Upper 1/3rd | 1 | 9% | 1 | 9.1% |
| Middle 1/3rd | 3 | 27.3% | 4 | 36.4% |
| Lower 1/3rd | 7 | 63.7% | 6 | 54.5% |
| Total | 11 | 100% | 11 | 100% |

As shown in table-5, in males, Type-A sural nerve formation was most commonly located at lower 1/3rd of leg with 63.7% specimens (n=7) on right side and 54.5% specimens(n=6) on left side. Total of 7 specimens had Type-A formation at middle 1/3rd of leg and 1 lower limb specimen on each side had Type-A formation at upper 1/3rd of leg.

**Table 6: Location of Type-A Sural Nerve Formation In Females**

| Location in Leg | Females | | | |
|---|---|---|---|---|
| | Right | | Left | |
| | N | % | N | % |
| Upper 1/3rd | 1 | 14.3% | 1 | 12.5% |
| Middle 1/3rd | 1 | 14.3% | 1 | 12.5% |
| Lower 1/3rd | 5 | 71.4% | 6 | 75% |
| Total | 7 | 100% | 8 | 100% |

As shown in table-6, in females, Type-A sural nerve formation was most commonly located at lower 1/3rd of leg with 71.4% specimens (n=5) on right side and 75% specimens(n=6) on left side. Total of 2 specimens had Type-A formation at middle 1/3rd of leg and another 2 specimens had Type-A formation at upper 1/3rd of leg.

**Symmetry of Formation of Sural Nerve**

**Table 7: Symmetry of Sural Nerve Formation**

| Symmetricity | Males (N = 14) | | Females (N=11) | |
|---|---|---|---|---|
| | N | % | N | % |
| Symmetry | 11 | 78.6% | 6 | 54.5% |
| Asymmetry | 3 | 21.4% | 5 | 45.5% |
| Total | 14 | 100% | 11 | 100% |

As shown in table-7, in our study the symmetricity of sural nerve formation between right and left lower limbs was noted in 11 male cadavers (78.6%) and 6 female cadavers (n=54.5%). Sural nerve formation was asymmetric in 3 male (21.4%) and 5 female (45.5%) cadavers.

**Site of Piercing Deep Fascia**

**Table 8: Site of Sural Nerve Piercing Deep Fascia**

| Site Of Piercing Deep Fascia | Males (N =28) | | Females (N=22) | |
|---|---|---|---|---|
| | N | % | N | % |
| Upper 1/3rd | 3 | 10.7% | 2 | 9.1% |
| Middle 1/3rd | 11 | 39.3% | 9 | 40.9% |
| Lower 1/3rd | 14 | 50% | 11 | 50% |
| Total | 28 | 100% | 22 | 100% |

As shown in table-8, in our study, sural nerve pierced deep fascia most commonly at lower 1/3rd of leg as noted in 50% of specimens (Males n=14, Females n=11). Deep fascia was pierced in middle1/3rd of leg in 11 male

specimens (39.3%) and 9 female specimens (40.9%). Least common site was the upper 1/3rd of leg noted in total 5 specimens.

**Distance between Site of Sural Nerve Piercing Deep Fascia and Lower Border of Lateral Malleolus**

**Table 9: Distance between Site of Sural Nerve Piercing Deep Fascia and Lower Border of Lateral Malleolus (in cm)**

| | |
|---|---|
| N | 50 |
| Mean | 18.07 |
| Median | 18.45 |
| Standard Deviation | 5.64 |
| Minimum | 10.20 |
| Maximum | 33.10 |
| Range | 22.90 |
| Standard Error | 0.79 |

As shown in table-9, the mean distance between the site of sural nerve piercing deep fascia and lower border of lateral malleolus was 18.07 cm with a standard deviation of 5.64. The minimum and maximum distances were 10.2 cm and 33.1 cm respectively with a range of 22.9 cm.

**Length of Sural Nerve**

**Table 10: Length of Sural Nerve (in cm)**

| | **All (N=50)** | **Males(N=28)** | **Females(N=22)** |
|---|---|---|---|
| Mean | 31.54 | 32.88 | 29.82 |
| Median | 32.45 | 34.40 | 30 |
| Standard Deviation | 7.01 | 7.21 | 6.52 |
| Minimum | 20.40 | 21.60 | 20.40 |
| Maximum | 45.10 | 45.10 | 41.60 |
| Range | 24.70 | 23.50 | 21.20 |
| Standard Error | 0.99 | 1.36 | 1.39 |

As shown in table-10, the mean length of sural nerve measured from its formation to lateral malleolus was 31.54 cm with standard deviation of 7.01. In male cadaver lower limb specimens, the minimum and maximum length were 21.6 cm and 45.1 cm respectively with mean length of 32.88 cm. In females, the minimum and maximum length was 20.4 cm and 41.6 cm respectively with mean length of 29.82 cm.

**Relation with Lateral Malleolus**

**Table 11: Distance between Sural Nerve and Posterior Margin of Lateral Malleolus (in cm)**

| | |
|---|---|
| N | 50 |
| Mean | 0.98 |
| Median | 0.95 |
| Standard Deviation | 0.31 |
| Minimum | 0.40 |
| Maximum | 1.50 |
| Range | 1.10 |
| Standard Error | 0.04 |

As shown in table-11, the mean distance between sural nerve and posterior border of lateral malleolus at its midpoint was 0.95 cm with a standard deviation of 0.31. The minimum and maximum distances were 0.4 cm and 1.5 cm respectively with a range of 1.1 cm.

**Relation with Tendo-Calcaneus**

**Table 12: Distance between Site of Sural Nerve Crossing Lateral Border of Tendo-Calcaneus and Lower Border of Lateral Malleolus (in cm)**

| | |
|---|---|
| N | 50 |
| Mean | 4.82 |
| Median | 4.95 |
| Standard Deviation | 1.65 |
| Minimum | 2.20 |
| Maximum | 7.60 |
| Range | 5.40 |
| Standard Error | 0.23 |

As shown in table-12, the mean distance between the site of sural nerve crossing lateral border of Tendo-calcaneus and lower border of lateral malleolus was 4.82 cm with a standard deviation of 1.65. The minimum and maximum distances were 2.2 cm and 7.6 cm respectively with a range of 5.4 cm

**Table 13: Horizontal Distances of Sural Nerve to Lateral Border of Tendo-Calcaneus at 3 Reference Points (in cm)**

| | **5 cm From Heel** | **7 cm From Heel** | **10 cm From Heel** |
|---|---|---|---|
| Mean | 0.17 | -1.50 | -3.92 |
| Median | 0.5 | -2 | -4.10 |
| Standard Deviation | 1.36 | 1.42 | 0.85 |
| Minimum | -2.4 | -3.80 | -5.40 |
| Maximum | 2.2 | 1.40 | -1.50 |
| Range | 4.6 | 5.20 | 3.90 |
| Standard Error | 0.19 | 0.20 | 0.12 |

As shown in table-13, the mean distance between lateral border of Tendo-calcaneus and sural nerve were measured at three reference points at 5cm, 7cm and 10 cm from heel. The mean distances noted at 5cm reference point was 0.17 cm lateral to Tendo-calcaneus. At 7cm and 10cm reference points, sural nerve was medial to lateral border of Tendo-calcaneus with mean distances -1.5cm and -3.92 cm respectively.

**Discussion**

The importance of Sural nerve in relation to Tendo-calcaneus is worth to know, as it is frequently injured during Tendo-calcaneus rupture repair. So during any repair of Tendo-calcaneus the knowledge of exact proximity of Sural nerve with Tendo-calcaneus and if any crossing of the nerve to medial side in relation to Tendo-calcaneus will be of immense help for surgeons.

Accordingly, a review of previous studies on sural nerve along with observations made in the present study is assessed through following important parameters.

**1. Comparision of Sural Nerve Formation**

Pyun S-B et al (2008) [11] : The sural nerve was formed by the anastomosis of the MSCN and LSCN in the calf in 20 out of 26 legs (76.9%). The sural nerve was a direct continuation of the MSCN in four (15.4%) cases, and there was no communication between the MSCN and LSCN in two cases (7.7%). Kavyasree et al (2013) [12]: Out of 50 specimens Type- A formation was noted in 36 (72%), Type-B formation was noted in 14 (28%) and none of the specimens had Type-C formation.

Otto Riedl et al (2013) [13]: Authors categorized sural nerve formation into four patterns. In pattern I [*n*=19 (63 percent)], the medial sural cutaneous nerve (i.e., tibial nerve component) and peroneal communicating branch (i.e., common peroneal nerve component) merged to form a common sural nerve.

In patterns II and III, the medial sural cutaneous nerve (tibial nerve component) alone represented the sural nerve [*n* _ 10 (33 percent)]; the lateral sural cutaneous nerve coursed independently [*n* _ 8 (27 percent); pattern II] or was absent [*n* _ 2 (7 percent); pattern III]. In pattern IV [*n* _ 1 (3 percent)], the lateral sural cutaneous nerve (common peroneal nerve component) represented the sural nerve—the medial sural cutaneous nerve terminated subcutaneously in the distal calf.

Seema SR (2013) [14]: In 40% of the cases there was no communication between MSCN and PCN. In these cases, PCN was considered as absent. In 39% of the cases sural nerve was a continuation of MSCN alone. In 1% of the cases lateral sural cutaneous nerve (LSCN) continued as sural nerve. In 5% of the cases both PCN and LSCN were absent.

PreetiAwari et al (2017) [15]: In 60% of lower extremities the MSCN joined with the LSCN to

form the sural nerve. In 40% of legs MSCN continued as the sural nerve on the dorsum of the foot. In 30% of legs the MSCN passed through the gastrocnemius muscle instead of passing superficial to it.

**Table 14: Types of Sural Nerve Formation**

| Author | Number of Cases | Type-A | Type-B | Type-C |
|---|---|---|---|---|
| William et al (1954) [18] | 257 | 83.7% | 15.9% | 0.4% |
| Heulke et al (1958) [16] | 198 | 80.3% | 19.2% | 0.5% |
| Mestdagh et al. (2001) [21] | 37 | 67.6% | 24.3% | 8.1% |
| Seema SR (2013) [14] | 100 | 60% | 39% | 1% |
| Present Study | 50 | 74% | 24% | 2% |

According to Heulke et al.[16] formation of SN was broadly classified into three types: Types A, B, and C.

- In Type A – Sural Nerve was formed by the union MSCN of tibial nerve and PCN/LSCN 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 – Sural Nerve was continuation of the MSCN and the PCN was absent.
- In Type C – Sural Nerve was formed only by the LSCN/PCN.

According to the studies of Coert and Dellon et al.[17], Williams DD et al.[18], Hollinshead et al.[19] and Uluttku et al.[20], a 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. They considered MSCN as Sural nerve only.

In our study, Type A Sural Nerve formation was more common.

Findings of our study are similar to the finding of the study done by William et al.[18], Heulke et al.[16], Mestdagh et al.[21], Seema SR et al.[14]. Sural nerve was formed by union of MSCN and LSCN in 74%. Depending upon the formation of sural nerve the point of intersection of sural nerve with the lateral border of Achilles tendon also varies. Complications related to Tendo-calcaneus repair, particularly injury to sural nerve may be avoided if approximate intersection point is known.

**2. Comparison of Location of Sural Nerve Formation in Relation to Upper, Middle and Lower 1/3rd Parts of Leg**

Huelke et al. (1958)[16]: Authors found that in 75% of the cases, the union of the medial sural cutaneous nerve with peroneal communicating nerve in the distal half of the leg.

Ortiguela et al. (1987)[22]: Authors found that the union of the medial sural cutaneous nerve with peroneal communicating nerve was in the distal 1/3 of the leg in the majority of the cases.

Uluutku et al. (2000)[20]: Authors found that in majority of cases (81.8%) the union between MSCN and PCN was at the middle 1/3rd of the leg and remaining 20% in the distal 1/3rd of leg.

Mestdagh et al. (2001)[21]: Authors found that the communication between MSCN and PCN/LSCN was most often at the junction between the proximal two-thirds and distal third of the leg.

Mahakkanukrauh and Chomsung (2002) [23]: Most common site of sural nerve formation was at the lower 1/3rd of leg and ankle. Results showed the site of formation were 5.9% in the popliteal fossa, 1.9% in the middle third of the leg, 66.7% in the lower third of the leg, and 25.5% at or just below the ankle.

Pyun S-B et al (2008) [11]: Authors noted that the site of sural nerve formation was most common in lower 1/3rd of leg. 20 specimens were dissected. Sural nerve formation was noted in middle 1/3 in 9 specimens and in lower 1/3 in 11 specimens.

Essam M. Eid et al (2010) [2]: Out of 21 specimens dissected, in 9.5% formation was noted in the upper one-third of the leg (in popliteal fossa), 28.6% in the middle one-third of the leg, 52.4% in the lower one-third of the leg and 9.5% at the level of ankle joint.

Albay et al. (2012) [24]: studied the level union was at the distal third of the legin 43% of the cases, at the middle third of the leg in 46% of the cases, and at the upperthird of the leg in 11% of the cases.

Kavyasree et al (2013) [12]: Site of union of components of SN was seen in the upper 1/3rd of leg in 5.6%, in middle 1/3rd of leg in 33.3% and in lower 1/3rd of leg in 58.3% of cases.

Seema SR et al(2013) [14]: In this study the most common site of sural nerve formation was located at the distal 1/3rd of leg. Out of 100 specimens dissected, in 2% formation was noted in the in popliteal fossa, 20% in the middle one-third of the leg, 38% in the distal one-third of the leg.

PreetiAwari et al (2017)[15]: 50 specimens were dissected. Sural nerve formation was noted in upper 1/3 of leg in 4%, middle 1/3 in 22% and in lower 1/3 in 34% of specimens.

**Table 15: Location of Type-A Sural Nerve Formation**

| Author | Upper 1/3rd | Middle 1/3rd | Lower 1/3rd |
|---|---|---|---|
| Huelke et al [16] | 24.3% | 53.5% | 22.2% |
| Pyun and Kwon et al [11] | 6.9% | 62.2% | 30.9% |
| Mahakkanukrauh et al [23] | 5.9% | 1.9% | 67.4% |
| Kavyashree et al [12] | 2.8% | 38.9% | 58.3% |
| Present Study | 10.8% | 24.3% | 64.9% |

As shown in table-15, in our study, the sural nerve formation was more common in the lower1/3rd rather than upper 1/3rd or middle1/3rd. Sural nerve formation was found most commonly in lower 1/3rd of leg in 64.9% (n=37) of specimens followed by middle 1/3rd of leg in 24.3% (n=9) of specimens.

The present study's findings are similar to that of the studies done by Mahakkanukrauh et al [23]., Kavyashree et al [12]. In contrast, Huelke et al [16] and Pyun and Kwon et al [11] found middle 1/3rd of leg as the most common site of sural nerve formation.

### 3. Comparision of Symmetry of Sural Nerve Formation

Kavyasree et al (2013)[12]: Symmetrical group of cadavers had the same type of formation of sural nerve 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 this study, the symmetrical distribution of sural nerve was seen in 62.5% in males and 55.6% in female. When compared in both the sexes, Type A was commonly found. Distribution of symmetry and asymmetry were statistically similar between male and female cadavers.

**Table 16: Symmetry of Sural Nerve Formation**

| Author | Population | Number of Cases | Symmetry | Asymmetry |
|---|---|---|---|---|
| Heulke et al [16] | American | 150 | 82.7% | 17.3% |
| Tan ACK et al [25] | Chinese | 143 | 83.9% | 16.1% |
| Mogi et al [28] | Japanese | 90 | 82.2% | 17.8% |
| Ssokolow et al [29] | Russian | 250 | 78.8% | 21.2% |
| Kavyashree et al [12] | Indian | 25 | 60% | 40% |
| Present study | Indian | 50 | 68% | 32% |

As shown in table-16, the cadaver specimens with symmetrical sural nerve formation had Type-A formation in both lower limbs. Those cadavers with asymmetrical formation had Type-A formation in one lower limb and either Type-B or Type-C in the other lower limb. In our study, the symmetry in sural nerve formation in right and left limb of same cadaver was more common than asymmetry. Similarly symmetric formation was most common in studies done by Heulke et al [16], Tan ACK et al [25], Mogi et al [28], Ssokolow et al. [29]. The present study is more similar to study done by Kavyashree et al [12] with 68% (n=17) of cadavers showed symmetric sural nerve formation in both lower limbs. As noted from table-16, in American, Chinese, Japanese and Russian studies, the percentage of symmetry is higher compared to the present study. This could probably be due to the small sample size and study group from Indian population.

### 4. Site of Piercing Deep Fascia

Kavyasree et al (2013) [12]: In this study the point at which sural nerve 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 ± 2 Standard Deviation = 20.86 ±12.88).

Otto Riedl et al (2013) [13]: MSCN coursed parallel to the tibial nerve and entered a groove between the two heads of the gastrocnemius covered by the crural fascia. MSCN emerged out of this musculoaponeurotic channel and pierced the fascia at the musculotendinous junction of the gastrocnemius.

The exact height varied, with an average distance of 20 cm to the distal tip of the lateral malleolus. The fascia penetration site of sural nerve was characterized by a fibrous arcade.

**Table 17: Site of Sural Nerve Piercing Deep Fascia**

| Site of Piercing Deep Fascia | Kavyashree et al [12](2013) | Present Study |
|---|---|---|
| Upper 1/3rd | 8.3% | 10% (n=5) |
| Middle 1/3rd | 33.3% | 40% (n=20) |
| Lower 1/3rd | 58.3% | 50% (n=25) |

Sural nerve is formed commonly either by the communication of MSCN with PCN or as a direct continuation of MSCN. Then it pierces the deep fascia to become superficial in its further course. As shown in table-17, in our study it pierced deep fascia most commonly at lower 1/3rd of leg in 50% of cases (n=25) followed by middle 1/3rd of leg in 40% of cases (n=20). As shown in table-17, Results of our study were similar to the findings of Kavyashree et al [12] with sural nerve piercing deep fascia in lower 1/3rd of leg in 58.3% of cases.

**Table 18: Site of Sural Nerve Piercing Deep Fascia**

| | **Kavyashree et al [12] (2013)** | **Present Study** |
|---|---|---|
| Distance between | Sural nerve piercing deep fascia and fibular head in cm | Sural nerve piercing deep fascia and lower border of lateral malleolus in cm |
| Mean | 20.86 | 18.07 |
| Standard Deviation | 12.88 | 5.64 |
| Minimum | 5 | 10.2 |
| Maximum | 32 | 33.1 |

As shown in table-18, in our study, the mean distance between the site of sural nerve piercing deep fascia and lower border of lateral malleolus was 18.07 cm with a standard deviation of 5.64 and the values varied between 10.2 cm and 33.1 cm.

In comparison, in the study by Kavyashree et al [12] (2013) the point at which sural nerve pierced deep fascia was measured from the level of fibular head and the values varied between 5 cm and 32 cm with mean distance of 20.86 cm.

**5. Length of Sural Nerve**

Seema SR (2013) [14]: Length of the medial sural cutaneous nerve ranges from minimum 6 cms to maximum 43 cms. Length of peroneal communicating nerve ranges from 2.5 cms to 39 cms, lateral sural cutaneous nerve from 8.5 cms to 40 cms, and sural nerve from 3.5 cms to 39.5 cms.

Kavyasree et al (2013) [12]: This study showed a wide range of difference in the length of the sural nerve. Mean length of sural nerve in this study was 19.02 cm with a standard deviation of 15.32. In males, the length of sural nerve ranges from 7-32 cm on right and 8-26 cm on left. In females it ranges 8-32 cm on right and 10-32 cm on left.

**Table 19: Length of Sural Nerve**

| **Study** | **Length of Sural Nerve** |
|---|---|
| Ortiguela et al [22] | 11 to 20 cm |
| Mahakkanukrauh P et al [23] | 6 to 30 cm |
| Kavyashree et al[12] | 2 to 32 cm |

**Table 20: Length of Sural Nerve**

| **Length of Sural Nerve** | **Kavyashree et al [12]** | **Present Study** |
|---|---|---|
| Mean | 19.02 | 31.54 |
| Standard Deviation | 15.32 | 7.01 |
| Males | 7 – 32 | 21 – 45 |
| Females | 8 – 32 | 20 – 41 |

The mean length of sural nerve was measured from its formation to the level of lower border of lateral malleolus. The present study showed wide variations in sural nerve length ranging from 20.4 cm to 45.1 cm.

In the present study, the mean length of sural nerve was 31.54 cm with standard deviation of 7.01. In comparison, in the study by Kavyashree et al [12] the mean length was 19.02cm with standard deviation of 15.32 as shown in table-20.

**Distance between Sural Nerve and Posterior Margin of Lateral Malleolus**

Sural nerve is commonly used for both nerve biopsy and nerve conduction velocity studies for diagnostic purposes. It is also used for therapeutic purposes like nerve grafting.

The consistent location of the sural nerve, around 1-1.5 cm behind the posterior border of lateral malleolus provides a precise location for electrode placement for sensory nerve conduction studies and also for surgical approach.

Otto Riedl et al (2013) [13]: **S**ural nerve lies behind the lateral malleolus with the averageof 13 mm from its dorsal edge.

**Table 21: Distance between Sural Nerve and Posterior Margin of Lateral Malleolus**

| Distance Between Sural Nerve and Posterior Border of Lateral Malleolus | Essam M.Eid et al [2] | Present Study |
|---|---|---|
| Mean | 1.9 | 0.98 |
| Standard Deviation | 0.4 | 0.31 |
| Minimum distance | 1.5 | 0.4 |
| Maximum distance | 2.5 | 1.5 |
| Range | 1 | 1.1 |

In our study, the distance between posterior border of lateral malleolus and sural nerve was measured at the level of centre of lateral malleolus. In our study, the mean distance between sural nerve and posterior border of lateral malleolus was 0.95 cm with a standard deviation of 0.31. Values ranges from 0.4 cm to 1.5 cm. As shown in table-21, our results were comparable to study from Egypt by Essam M.Eid et al [2].

**6. Relation Between Sural Nerve and Tendo-Calcaneus**

Essam M. Eid (2010) [2]: In 41.7%, the sural nerve descended in front and parallel to the lateral border of calcaneal tendon. In 37.5%, the sural nerve descended superficial to the proximal part of the calcaneal tendon and then inclined toward its lateral border crossing it, two inches above the level of its insertion. In 12.5%, the sural nerve descended superficial to the major part of the calcaneal tendon and then crossed its lateral border, one inch above its insertion. In 8.3%, the sural nerve descended vertically very close to the lateral border of calcaneal tendon. In 91.7%, the distance between the sural nerve and the lower end of lateral border of calcaneal tendon was 16±7 mm. Blackmon JA et al. (2013) [27]: Authors estimated the intersection point at which the sural nerve crosses the lateral border of the Tendo-calcaneus, an important surgical landmark through 107 cadaveric leg dissections. Usually the sural nerve crosses the lateral border of the Achilles tendon 8 to 10 cm proximal to the superior border of the calcaneal tuberosity.

By measuring the leg length of the patient (from the flexor crease of the popliteal fossa to the base of heel), this intersection point can be approximated with an interval length of 0.68 to 1.80 cm with 90% confidence interval or 0.82 to 2.15 cm with 95% confidence interval. The results of this study offer surgeons a simpler method to locate reliably and subsequently avoid damage to the sural nerve during Tendo-calcaneus repair.

Alvin Chin Kwong Tan et al (2017) [25]: The sural nerve crosses the lateral border of the Tendo-calcaneus with a mean and median longitudinal distances of 9.9cm and 10cm respectively with a range of 7cm to 14cm from the calcaneal tuberosity. The mean and median longitudinal distances where the gastrocnemius tendon inserts into the Tendo-calcaneusare 19.9cm and 18.5cm respectively with a range of 17cm to 25cm.

In our study, the mean distance between the point at which sural nerve crosses lateral border of Achilles tendon and lower border of lateral malleolus was found to be 4.82 cm with a standard deviation of 1.65.

The values range from 2.2 cm to 7.6 cm. In comparison, Essam M.Eid et al [2] found that sural nerve crosses lateral border of calcaneal tendon 2 inches above its insertion in 37.5% cases and 1 inch above its insertion in 12.5% cases.

**Table 22: Distance between Sural Nerve Crossing Lateral Border of Achilles Tendon and Lateral Malleolus**

| Reference Points | Mean Horizontal Distances of Sural Nerve to Lateral Border of Achilles Tendon | |
|---|---|---|
| | Joseph A. Blackmon et al [27] | Present Study |
| 2 cm | 1.19 | |
| 4 cm | 0.77 | |
| 5 cm | | 0.17 |
| 6 cm | 0.38 | |
| 7 cm | | -1.5 |
| 8 cm | 0.04 | |
| 10 cm | -0.32 | -3.92 |
| 12 cm | -0.67 | |
| 14 cm | -1.09 | |

The mean distance between lateral border of Tendo-calcaneus and sural nerve were measured at three reference points at 5cm, 7cm and 10 cm from heel. Negative values denote sural nerve had not

crossed lateral border of Tendo-calcaneus and was medial to its lateral border.

As shown in table-22, the mean distances noted at 5cm reference point was 0.17 cm lateral to Tendo-calcaneus. At 7cm and 10cm reference points, sural nerve was medial to lateral border of Tendo-calcaneus with mean distances -1.5cm and -3.92 cm respectively. In comparison, Joseph A, Blackmon et al [27] in 2013 studied mean distances between Tendo-calcaneus and sural nerve with 8 reference points based on calcaneal tuberosity.

In our cadaveric study, we identified the location at which the sural nerve crossed the lateral border of the calcaneal tendon (intersection point). This will enable surgeons doing Tendo-calcaneus repair to identify its location with confidence. These data provide the surgeon with a "danger zone" to avoid damage to the sural nerve when making incisions, placing retractors, or passing sutures along the lateral border of the Tendo-calcaneus. When combined with other clinical and ultrasound methods of localizing the sural nerve, these data provide surgeons with another tool that is less intensive, to approximate the location of the sural nerve to avoid iatrogenic damage during operative procedures.

**Conclusion**

A thorough knowledge of anatomical variations in sural nerve formation, length, course, its relation to gastrocnemius, deep fascia, Tendo-calcaneus and lateral malleolus is important for Orthopaedicians, Neurosurgeons, Neurologists, Anatomists and Radiologists. The following conclusions were drawn from the present study.

1. The most common type of formation of sural nerve in the present study was observed to be type A, which is formed by union of medial sural cutaneous nerve and the peroneal communicating nerve.74% of specimens found to have type A formation.
2. The most common site of formation of sural nerve was found to be at the lower one third of the leg in both males and females followed by middle one third of the leg in the present study.
3. In the present study it was observed that symmetry in the sural nerve formation was about 68% and asymmetry was observed in 32% of the legs.
4. Most common site of sural nerve piercing deep fascia was observed to be in the lower one third of the leg followed by middle one third of the leg in the present study. It was also observed that mean distance between the site of piercing deep fascia and lower border of lateral malleolus was 18.1 cm. The minimum and maximum distances were 10.2cm and 33.1cm respectively.
5. The mean length of the sural nerve was observed to be 31.54cm with the minimum and maximum length of about 21.6cm and 45.1 cm respectively in males. In females, it was about 20.4cm and 41.6cm respectively.
6. The mean distance between the site of sural nerve crossing lateral border Tendo-calcaneus and lower border of lateral malleolus was 4.82cm in the present study. The minimum and maximum distances were observed to be 2.2cm and 7.6cm respectively.
7. The mean maximum distance between the sural nerve and posterior border of the lateral malleolus was 0.95cm. The minimum and maximum distances were 0.4cm and 1.5cm respectively.
8. The mean distance between the lateral border of Tendo-calcaneusand the sural nerve at three reference points were observed in the present study.The reference points were 5cm,7cm and 10cm from the heel. The mean distance noted at these reference points were 0.17cm ,-1.5cm and -3.92cm respectively.

A thorough knowledge of sural nerve formation and its variations at different levels in the leg will help the surgeon to carry out any therapeutic or diagnostic procedure on Tendo-calcaneusor sural nerve itself. In the repair of Tendo-calcaneus, the Sural nerve is at high risk in getting injured.

In the present study, an attempt is made to know the variations of Sural Nerve formation, the exact location of its formation, symmetricity on both the sides of same cadaver, length of leg and the exact distance of sural nerve in relation to lateral border of Tendo-calcaneus.

The present study concludes that different type of Sural nerve variations in the cadavers and the close relation of Sural nerve with Tendo-calcaneusat given point which have been studied would be of immense help for successful Tendo-calcaneus rupture repair without injuring sural nerve which is a common complication.

**References**

1. L. H. Bannister, M. M. Berry, P. Collins et al., Gray's Anatomy. The Anatomical Basis of Medicine and Surgery, Churchill & Living-stone, 38th edition, 1995.
2. E. M. Eid and A. M. S. Hegazy, "Anatomical variations of the human sural nerve and its role in clinical and surgical procedures," Clinical Anatomy, vol. 24, no. 2, pp. 237–245, 2011.
3. M. E. Ortiguela, M. B. Wood, and D. R. Ca-hill, "Anatomy of the sural nerve complex," Journal of Hand Surgery, vol. 12, no. 6, pp. 1119–1123, 1987.
4. Bannister LH, Berry MM, Collins P. Gray's Anatomy. The Anatomical Basis of Medicine

and Surgery. 38th edn. New York: Churchill and Livingstone; 1995.
5. Connolly ES. Techniques of diagnostic nerve and muscle biopsies. In: Neurosurgery, Wilkins RH, Rengachary SS (eds.), 2nd edn. New York: McGraw- Hill; 1996. pp.3243-4.
6. Olney RK. Use of neurophysiologic techniques in clinical trials. In: Electrodiagnosis in Clinical Neurology, MJ Aminoff (ed.), 4th edn. New York: Churchill Livingstone; 1999. pp.708-10.
7. Li Z, Liu K, Lin Y, Li L. Lateral sural cutaneous artery island flap in the treatment of soft tissue defects at the knee. Br J PlastSurg 1990; 43:546-50.
8. McGillicuddy JE. Techniques of nerve repair. In: Neurosurgery, Wilkins RH, Rengachary SS (eds.), 2nd edn. New York: McGraw-Hill; 1996. pp.3185-6.
9. Walton RL, Bunkis J. The posterior calf fasciocutaneous free flap. Plastic Reconstruction Surgery 1984; 74:76-85.
10. Wei FC, Chuang SS, Yim KK. The sensate fibula osteoseptocutaneous flap: a preliminary report. Br J PlastSurg 1994; 47:544-7.
11. S.-B. Pyun and H.-K. Kwon, "The effect of anatomical variation of the Sural nerve on nerve conduction studies," American Journal of Physical Medicine and Rehabilitation, vol. 87, no. 6, pp. 438–442, 2008.
12. Kavyashree AN, Lakshmi Prabha Subhash, Asha KR, Bindu Rani MK. Variationsin Formation of Sural Nerve in Adult Indian Cadaver. Journal of Clinical andDiagnostic Research 2013 Sep;7(9):1838-41.
13. Riedl O, Frey M. Anatomy of the sural nerve: cadaver study and literature review. PlastReconstr Surg. 2013 Apr;131(4):802-810.
14. S. R. Seema, "Study of Sural Nerve Complex in Human Cadavers", International Scholarly Research Notices, vol. 2013, Article ID 827276, 7 pages, 2013.
15. Dr. PreetiAwari and Dr.Vatsalaswamy, P. 2017. "Variant sural nerve formation with surgical significance", International Journal of Current Research, 9:(07), 54936-54939.
16. D. F. Huelke, "The origin of the peroneal communicating nerve in adult man," The Anatomical Record, vol. 132, no. 1, pp. 81–92, 1958.
17. J. H. Coert and A. L. Dellon, "Clinical implications of the surgical anatomy of the sural nerve," Plastic and Reconstructive Surgery, vol. 94, no. 6, pp. 850–855, 1994.
18. Williams DD. A study of human fibular communicating nerve. Anat Rec. 1954; 120: 533-43.
19. H. W. Hollinshead, Anatomy for Surgeons, the Back and Limb, vol. 3, Hoeber-Happer, New York, NY, USA, 1958.
20. Uluutku, M, Can A, Kurtoglu Z. Formation and location of the sural nerve in thenewborn. Surgical and Radiologic Anatomy 2000;22(2):97-100.
21. Mestdagh H, Drizenko A, Maynou C, Demondion X, Monier R. Origin and makeup of the human sural nerve. SurgRadiolAnat 2001; 23:307-12.
22. Ortiguela ME, Wood MB, Cahill DR. Anatomy of the sural nerve complex. J Hand Surg 1987;12(6):1119-23.
23. P. Mahakkanukrauh and R. Chomsung, "Anatomical variations of the sural nerve," Clinical Anatomy, vol. 15, no. 4, pp. 263–266, 2002.
24. Albay S, Sakalli B, Kastamoni Y, Aydin I Candan, Kocabiyik N. Formation of the sural nerve in foetal cadavers. Folia Morphologica 2012;71(4).
25. Tan ACK, Tang ZH, Fadil MFBM. Cadaveric Anatomical Study of Sural Nerve: Where is The Safe Area for Endoscopic Gastrocnemius Recession? Open Orthop J. 2017 Sep 30; 11:1094-1098.
26. N K, Subhash LP, K R A, M K BR. Anatomical variations in formation of sural nerve in adult Indian cadavers. J Clin Diagn Res. 2013 Sep;7(9):1838-41.
27. Blackmon, JA, Stavros Atsas, Mackenzie J Clarkson, Jacob N Fox, Blake T Daney, Sean C Dodson, et al. Locating the Sural Nerve during calcaneal (Achilles) Tendon repair with confidence (A cadaveric study with clinical applications). The Journal of Foot and Ankle Surgery 2013; 52:42-7.
28. Mogi E. U¨ ber die sensiblen Wadennerven bei den japanischen Zwillingen. Okaj Folia Anat Jap. 1938; 16:229–274
29. Ssokolow P. Zur Anatomie des Nervus suralis beim Menschen und Affen. Z Gesamte Anat. 1933; 100:194–217.