

Morphological Evaluation of the Sural Nerve in Relation to The Achilles Tendon in Human Cadavers

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Abstract

Background: The sural nerve is an important sensory nerve of the lower limb frequently encountered during surgical procedures involving the Achilles tendon and posterolateral aspect of the ankle. Variations in its anatomical course in relation to the tendoachilles may increase the risk of iatrogenic nerve injury during orthopedic and reconstructive procedures. Detailed anatomical knowledge of the sural nerve is therefore essential for improving surgical safety and minimizing postoperative sensory complications. The aim is to study the anatomical relationship of the sural nerve with the tendoachilles in human cadavers and to evaluate its surgical significance. **Material and Methods:** This descriptive cadaveric study was conducted in the Department of Anatomy over a period of 12 months. A total of 45 lower limbs obtained from embalmed adult human cadavers were dissected and examined. Detailed dissection of the posterior compartment of the leg was performed to identify the sural nerve and its course in relation to the tendoachilles. Parameters assessed included the formation of the sural nerve, its distance from the lateral border of the tendoachilles at various levels, point of crossing, branching pattern, and anatomical variations. The collected data were analyzed statistically and expressed as mean, standard deviation, frequency, and percentage. **Results:** Among the 45 dissected lower limbs, the sural nerve was formed by the union of the medial sural cutaneous nerve and communicating branch in 34 (75.6%) specimens, while direct continuation without communicating branch was observed in 11 (24.4%) limbs. The mean distance of the sural nerve from the lateral border of the tendoachilles was 2.8 ± 0.5 cm at the musculotendinous junction and 1.2 ± 0.3 cm near the calcaneal insertion. Crossing of the sural nerve toward the lateral border of the tendoachilles was identified predominantly in the distal third of the leg in 29 (64.4%) specimens. Anatomical variations in branching pattern and communication were observed in 9 (20.0%) limbs. **Conclusion:** The sural nerve lies in close proximity to the Achilles tendon, particularly in the distal third of the leg, making it susceptible to iatrogenic injury during surgical interventions. Adequate anatomical knowledge of the sural nerve and its variations is essential for surgeons performing procedures around the tendoachilles to minimize postoperative sensory complications and improve surgical outcomes.

Keywords: Achilles tendon, Anatomy, Cadaver, Human lower limb, Sural nerve, Tendoachilles.

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INTRODUCTION

The sural nerve is an important sensory nerve of the lower limb that supplies the skin over the posterolateral aspect of the distal leg, lateral side of the foot, and lateral aspect of the fifth toe.^[1]

It is commonly formed by the union of the medial sural cutaneous nerve, arising from the tibial nerve, and the communicating branch from the common peroneal nerve. However, considerable anatomical variations exist in its formation, course, branching pattern, and relationship to surrounding structures.^[2] The variations are clinically important since the sural nerve is routinely encountered during orthopaedic, plastic, reconstructive, and minimally invasive surgeries involving the posterior aspect of the leg and ankle.^[3] The tendoachilles or Achilles tendon is the strongest and largest tendon of the human body. The superficial position of the tendoachilles in relation to the skin and its frequent involvement in various functional activities makes it vulnerable to many types of injury, including tendonitis, tendinosis and tendon rupture.^[4]

Tendinous operations performed at the Achilles tendon, such

as tendon reconstruction, tendon transfer, tendon repair, and percutaneous tenotomy are becoming a common practice in modern orthopaedics.^[5,6]

The surgical significance of the close anatomical association of the sural nerve with the tendoachilles is of great importance. The sural nerve is especially susceptible to iatrogenic damage due to its variable location on the lateral border of the Achilles tendon and may cause problems after the Achilles tendon procedure including postoperative pain, paresthesias, numbness, neuroma development, sensory deficit and functional discomfort on the lateral aspect of the foot. These can have a detrimental impact on

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the recovery process and patient satisfaction after surgery.^[7,8] Achilles tendon repair using percutaneous and minimally invasive surgery has become more popular in recent years due to minimized wound complications and quicker recovery times, but the high risk of sural nerve injury is possible, because the nerve itself is not always visible during the surgery.^[9] Hence, a correct knowledge of the anatomy of the sural nerve in relation to the tendoachilles is essential to create safer surgical areas and minimise the risk of nerve injury.^[10]

Cadaveric studies are useful to give information on anatomical variations and topographical relationships of nerves and tendons. These studies create a better anatomical orientation, surgical planning, and more secure operative techniques. Even though surgical corrections are becoming more frequent around the Achilles tendon, there is still a lack of information concerning the anatomical situation of the sural nerve in the region in many populations.

Aims and Objectives

To examine the relationship of sural nerve with the tendo Achilles in human cadaver and its surgical implications.

MATERIALS AND METHODS

A descriptive cadaveric analysis was carried out in the Department of Anatomy of SreeMookambika Institute of Medical Sciences for 12 months (from January 2025 to December 2025). The aim of this study was to assess the anatomical relationship between the sural nerve and the tendoachilles and to find variation in the formation, course and branching pattern of this nerve.

Overall, 45 lower limbs from embalmed adult human cadaver were studied. Lower limbs of male and female cadaver were used irrespective of sex on both the right and the left side. The lower limbs were dissected from cadaveric specimens of adults with good posterior compartment anatomy, and soft tissue structures were preserved. The study included lower limbs in which well-preserved sural nerve, tendoachilles and surrounding anatomical structures were seen.

The lower legs of animals with loss of integrity at the tibia, fibula, or femur from trauma, deformity, previous surgery,

congenital defects, advanced decay, and/or abnormal posterior compartments were excluded from the study. Others with lower leg amputation, torn tendoachilles or damaged neurovascular structures were also removed to prevent any inaccuracies in anatomical assessment.

The cadaver bodies were laid prone and the dissection of the posterior compartment of the leg was done as is common in anatomical dissection. Longitudinal incision was made, starting from the popliteal fossa to the calcaneal region along the mid-line. The sural nerve and tendoachilles were exposed by carefully reflecting the skin, superficial fascia and deep fascia. Identification and tracing of medial sural cutaneous nerve, communicating branch and sural nerve formation was done distally. It was a careful study of the course of the sural nerve, in relation to the lateral border of the tendoachilles, that was made. Digital Vernier calipers and measuring tape were used to take measurements. The lateral margin of the sural nerve to the tendon of Achilles' was measured at specific distances from the sural nerve beginning with the musculotendinous junction, middle of the tendon, and at a point near the calcaneal insertion. The location of the sural nerve crossing or approximation with the tendoachilles was recorded. The variability of formation, branching, communication and anatomical course of the sural nerve was recorded and photographed, whenever needed.

Data collected were tabulated and analysed by SPSS software 25. Means and standard deviations were used for quantitative variables and frequencies and percentages were used for qualitative variables. The anatomical variation and morphometric measurements were assessed by statistical analysis. The interpretation of the findings was done with a strong clinical and surgical emphasis on procedures on the tendoachilles and posterior part of the leg.

RESULTS

Right-sided lower limbs were slightly more common in the study. The classical union type was the predominant formation pattern of the sural nerve, while nearly one-fourth of specimens demonstrated direct continuation without communicating branch. [Table 1]

Table 1: Distribution of Specimens and Formation Pattern of the Sural Nerve

Parameter	Number (n=45)	Percentage
Side of specimen		
Right lower limb	24	53.3%
Left lower limb	21	46.7%
Formation pattern		
Union of medial sural cutaneous nerve and communicating branch	34	75.6%
Direct continuation of medial sural cutaneous nerve	11	24.4%

The sural nerve progressively approached the tendoachilles distally. The minimum distance was observed near the calcaneal insertion, indicating increased susceptibility to

nerve injury during distal Achilles tendon procedures. [Table 2]

Table 2: Mean Distance of Sural Nerve from Lateral Border of Tendoachilles

Anatomical Level	Mean Distance (cm)	SD
Musculotendinous junction	2.8	±0.5
Midpoint of tendoachilles	1.9	±0.4
Near calcaneal insertion	1.2	±0.3

The sural nerve crossed closest to the tendoachilles predominantly in the distal third of the leg. Anatomical

variations were observed in 20.0% of specimens, with branching variations being more common. [Table 3]

Table 3: Level of Crossing and Anatomical Variations of the Sural Nerve

Parameter	Number (n=45)	Percentage
Level of crossing		
Upper third of leg	5	11.1%
Middle third of leg	11	24.4%
Distal third of leg	29	64.4%
Anatomical variations		
Branching variations	5	11.1%
Communicating branch variations	4	8.9%
No significant variations	36	80.0%

A statistically significant reduction in distance between the sural nerve and tendoachilles was observed distally ($p <$

0.001). The closest relationship was identified in the distal third of the leg. [Table 4]

Table 4: Correlation Between Level of Crossing and Distance from Tendoachilles

Level of Crossing	Mean Distance from Tendoachilles (cm)	p-value
Upper third	2.9 ± 0.4	<0.001
Middle third	2.0 ± 0.3	
Distal third	1.1 ± 0.2	

No significant association was observed between side of limb and anatomical variations. However, distal crossing near the tendoachilles was significantly more common in specimens

with classical union-type formation of the sural nerve ($p = 0.03$). [Table 5]

Table 5: Correlation of Anatomical Variations and Formation Pattern

Parameter	Variations Present	Variations Absent	p-value
Side of limb			0.42
Right	6	18	
Left	3	18	
Formation pattern			0.03
Union type	25	9	
Direct continuation type	4	7	

DISCUSSION

A total of 45 cadaveric lower limbs were examined to evaluate the anatomical relationship of the sural nerve with the tendoachilles and to document its formation patterns and morphometric variations. During lateral ankle surgery and Achilles tendon surgery, the present study showed that the sural nerve has a consistent association with the lateral edge of the tendoachilles, especially in the distal third of the leg. There was no significant side predilection with 24 (53.3%) of the limbs being right-sided and 21 (46.7%) being left-sided. In the present study, union of the medial sural cutaneous nerve with a communicating branch was observed in 34 (75.6%) of the specimens with direct continuation of the nerve without any communicating branch seen in 11 (24.4%) specimens. These results underline the classical formation pattern, but also show significant anatomical variation that could affect the trajectory of the nerves and their vulnerability to iatrogenic injury. The same type of nerve formation variation was found in several anatomic studies. Sural nerve formation was found by Steele R et al in a wide range, the most dominant being type 1 (41.35%) and type 3 (34.62%) with asymmetry noted in 57.69%. They have also found some variants that have not been classified before, highlighting the complexity and variability of the anatomy of the sural nerve. The results of the present study corroborate

the above that the formation of sural nerves is not uniform, and there are multiple patterns, some of which have relevance in surgery. According to Harangee et al,^[12] there were 4 types of formations of which type 1 was most common (62.2%) and it was most commonly seen in the middle third of the leg. They also mentioned that they only observed bilateral symmetry in 40% of cases and noted the significance of nerve grafting procedure variability. The present study's results concur with these observations, which found that the dominant formation of the unions was of the union type, with the branching patterns being variable. The present study showed that the approximation of the sural nerve to the tendoachilles gradually occurred towards the distal end, and in most specimens, it was seen to be close to the distal insertion of the tendoachilles. More than half the limbs (64.4%) showed that the sural nerve had crossed over the posterior midtarsal space in the distal third of the leg, which is an area at high risk for iatrogenic injury during minimally invasive repair of the Achilles tendon. This anatomical relationship is of clinical importance because the procedure of the nerves performed percutaneously in this area can be a threat to the nerve. Kammar H et al,^[13] showed that the sural nerve was increasingly close to the Achilles tendon distally, that from proximal to distal levels of the nerve and that age and sex affected these distances. They also described anatomical variants where the nerve crosses the tendon at different levels, supporting the present study's

observation of distal vulnerability and crossing patterns. Apaydin N et al,^[14] reported that in 95.5% of specimens, the sural nerve was medial to the lateral border of the tendoachilles proximally and crossed near the mid-tendon region, with branching occurring near the distal segment. They emphasized that sutures placed distal to the mid-tendon line may reduce nerve injury, which correlates strongly with the findings of the present study regarding distal crossing and surgical risk zones. Anatomical variations in the present study were observed in 9 (20.0%) specimens, with branching variations in 11.1% and communicating branch variations in 8.9%. No complete absence of the sural nerve was noted. Variations were slightly more frequent on the right side; however, no statistically significant association was found between side and variation pattern. A statistically significant association was observed between formation pattern and distal crossing of the sural nerve near the tendoachilles ($p = 0.03$), indicating that classical union-type formation is more likely to be associated with closer distal proximity.

Garção DC et al,^[15] in a meta-analysis reported Type 2A (63.68%), Type 1A (51.17%), and Type 1B (32.19%) as the most common sural nerve formation patterns, with the lower and middle thirds of the leg being the predominant formation sites. They also highlighted significant variability in nerve length and course, reinforcing the anatomical unpredictability observed in the present study. Lama CP et al,^[16] described detailed morphometric variations of the Achilles tendon, emphasizing its anatomical dimensions and asymmetry between sides, which indirectly supports the relevance of precise tendon-nerve spatial relationships during surgical interventions. Appy-Fedida B et al,^[17] identified additional nerve structures such as the lateral calcaneal nerve and reported significant variations in their distances from the sural nerve, further supporting the complex neuroanatomy of the posterolateral ankle region. The present study confirms that the sural nerve exhibits consistent yet variable anatomical relationships with the tendoachilles, with a predictable high-risk zone in the distal third of the leg.

CONCLUSION

Sural nerve maintains a close anatomical relationship with the tendoachilles, particularly in the distal third of the leg, where the risk of iatrogenic nerve injury is greatest during surgical procedures. The classical union-type formation of the sural nerve was the most common pattern, although notable anatomical variations in formation and branching were observed. Progressive reduction in the distance between the sural nerve and tendoachilles distally highlights the importance of careful surgical planning and dissection. Adequate anatomical knowledge of sural nerve variations is essential for minimizing postoperative sensory complications and improving surgical outcomes in Achilles tendon procedures.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Magalhães MJ. Anatomy of the Lower Limb Nerves. In: Lower Extremity Nerve Entrapments: Clinical Diagnosis and Treatment 2025 Jun 21 (pp. 49-75). Cham: Springer Nature Switzerland.
- Kosinski C. The course, mutual relations and distribution of the cutaneous nerves of the metatarsal region of leg and foot. *Journal of Anatomy*. 1926 Apr;60(Pt 3):274.
- Ellis H. The nerves of the leg and foot. *Anaesthesia & Intensive Care Medicine*. 2010 Mar 1;11(3):95-7.
- Winnicki K, Ochoła-Kłos A, Rutowicz B, Pękala PA, Tomaszewski KA. Functional anatomy, histology and biomechanics of the human Achilles tendon—A comprehensive review. *Annals of Anatomy-Anatomischer Anzeiger*. 2020 May 1;229:151461.
- Zabrzynski J, Zabrzynska A, Grzanka D. Tendon—function-related structure, simple healing process and mysterious ageing. *Folia morphologica*. 2018;77(3):416-27.
- Feng SM, Maffulli N, Oliva F, Saxena A, Hao YF, Hua YH et al. Surgical management of chronic Achilles tendon rupture: evidence-based guidelines. *Journal of orthopaedic surgery and research*. 2024 Feb 10;19(1):132.
- Hamada T, Toribatake Y, Okamoto S, Sakagoshi D, Ota T, Nishimura M. Positional relationship between the Achilles tendon and sural nerve on ultrasound. *Journal of Medical Ultrasonics*. 2023 Jul;50(3):441-6.
- Sharp E, Roberts M, Żurada-Zielińska A, Zurada A, Gielecki J, Tubbs RS et al. The most commonly injured nerves at surgery: A comprehensive review. *Clinical Anatomy*. 2021 Mar;34(2):244-62.
- Yan XJ, Zhang WH. Enhanced recovery after surgery protocols for minimally invasive treatment of Achilles tendon rupture: Prospective single-center randomized study. *World Journal of Orthopedics*. 2024 Dec 18;15(12):1191.
- Yammine K, Honeine MO, Alam AE, Assi C. Locating the danger zone to avoid injury to the sural nerve during Achilles calcaneal tendon repair. A systematic review of cadaveric studies with clinical implications. *Surgical and Radiologic Anatomy*. 2022 Aug;44(8):1131-8.
- Steele R, Coker C, Freed B, Wright B, Brauer P. Anatomy of the sural nerve complex: unaccounted anatomic variations and morphometric data. *Annals of Anatomy-Anatomischer Anzeiger*. 2021 Nov 1;238:151742.
- Harangee J, Venter G. Anatomy of the sural nerve in a sample of South African human adult cadavers. *Anatomy & Cell Biology*. 2026 Mar 1;59(1):11-20.
- Kammar H, Carmont MR, Kots E, Laver L, Mann G, Nyska M et al. Anatomy of the sural nerve and its relation to the Achilles tendon by ultrasound examination. *Orthopedics*. 2014 Mar 1;37(3):e298-301.
- Apaydin N, Bozkurt M, Loukas M, Vefali H, Tubbs RS, Esmer AF. Relationships of the sural nerve with the calcaneal tendon: an anatomical study with surgical and clinical implications. *Surgical and radiologic anatomy*. 2009 Dec;31(10):775-80.
- Garção DC, de Souza Paiva MS, Corcinio KS. Anatomical patterns of the sural nerve: a meta-analysis with clinical and surgical considerations. *Surgical and Radiologic Anatomy*. 2023 Jun;45(6):681-91.
- Lama CP, Chalise U, Shrestha A, Dhungel S. Morphometric profile of Achilles tendon in male—a cadaveric study. *Nepal Medical College Journal*. 2022 Jun 27;24(2):158-63.
- Appy-Fedida B, Vernois J, Krief E, Gouron R, Mertl P, Havet E. Risk of sural nerve injury during lateral distal Achilles tendinosis: A cadaver study. *Orthopaedics & Traumatology: Surgery & Research*. 2015 Feb 1;101(1):93-6.