

A cadaveric study on anatomical variations of the Sural nerve in the foot & ankle with relevance to surgical approaches

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Abstract

Methods: Variations of the sural nerve were observed during the routine dissection of human cadavers. A total of 50 lower limbs were dissected and variations of sural nerve course, branching and distribution in the leg and foot were documented.

Results: On the basis of formation and course, the sural nerve in the back of the leg was divided into six types and in the foot into two types.

Conclusion: Awareness regarding the anatomical variations of the sural nerve becomes clinically relevant especially when Ankle is surgically approached posterolaterally for fixation of posterior malleolar fractures, high lateral malleolar fractures in pronation injuries of ankle and in foot, calcaneal fracture exposures in both classical extensile and sinius tarsi approach and in surgical exposure of talus both from medial and lateral exposures and for corrective osteotomies of calcaneum, Lisfranc fracture fixation and for various osteotomies of midfoot and forefoot.

Key words: Medial sural cutaneous nerve, Lateral sural cutaneous nerve, Anatomical variations, Cadver dissection, Foot and Ankle surgical approaches.

Introduction

The sural nerve is a cutaneous afferent nerve originates in the leg, courses along the back of the leg, the lateral side of the foot and the little toe, supplying the skin over the back of the leg and lateral aspect of ankle and foot including little toe 1. The Medial Sural Cutaneous Nerve (MSCN) is a branch of tibial nerve whereas Lateral Sural Cutaneous Nerve (LSCN) is the branch of the common peroneal nerve. MSCN and LSCN join to form the sural nerve at various levels during its course. There are many variations reported of their formation and distribution reported by many workers [Table 1]. The knowledge of Anatomical variations has got a

significance as the sural nerve is popularly harvested as a nerve graft. It is also encountered in several minimally invasive and open surgical approaches over the posterolateral aspect of the leg, lateral aspect of the ankle and foot. A thorough anatomical knowledge can avoid iatrogenic injuries especially during portal placement in Ankle arthroscopy and percutaneous repair of Achilles tendon. Complications include referred pain, painful neuroma, and reflex sympathetic dystrophy [2,3].

The purpose of this study is to generate awareness while encountering sural nerve for various operative indications around foot and ankle by highlighting various anomalies in formation, course, and distribution of the sural nerve.

46 were males, and 4 were females. None of the limbs dissected showed any evidence of previous surgery. Two horizontal cutaneous incisions were made one at the level of the heel another on the back of the thigh at the junction of its upper and middle 1/3rds. Both horizontal incisions were connected with a vertical incision. After removal of the skin, in the subcutaneous tissue the sural nerve as well the other cutaneous nerves were identified and traced from its origin to the back of the lateral malleolus. The skin and fascia were reflected on the dorsum of the foot, and all the nerves supplying the dorsum of the foot were traced to their destination.

Results

Based on the formation and distribution of the sural nerve in the leg, we classified them into the following types

In the leg:

Type 1: The MSCN from tibial nerve descended in the lower part of popliteal

Materials & Methods

Our study included 50 cadaveric lower limb specimens which were formalin embedded and preserved. There were 28 right and 22 left side limbs of which

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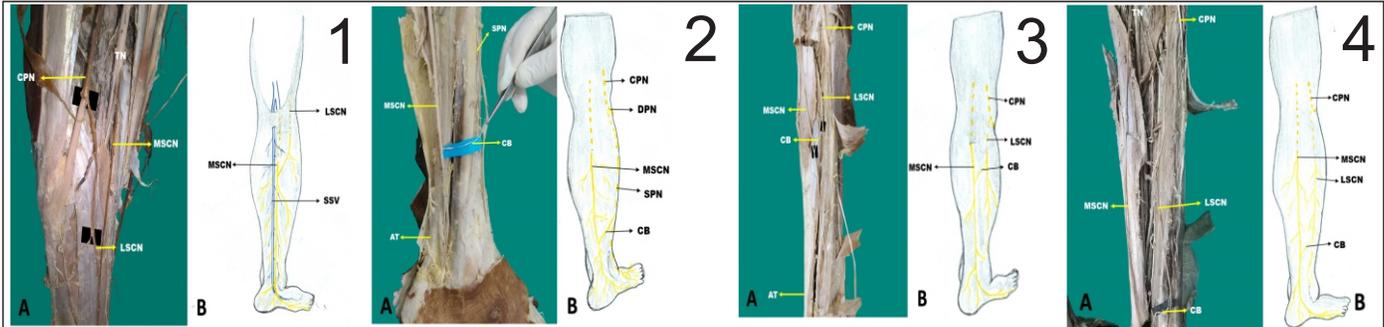


Figure 1A: Dissection of the popliteal fossa and back of the leg showing the origin and course of Medial Sural Cutaneous Nerve (MSCN) and Lateral Sural Cutaneous Nerve (LSCN); CPN- Common Peroneal Nerve **Figure 1B:** Schematic representation of the course of MSCN and LSCN; SSV-Short Saphenous Vein.

Figure 2A: Dissection of lateral aspect of the leg showing the Superficial Peroneal Nerve (SPN) descending in the peroneal tunnel and communicating with Medial Sural Cutaneous Nerve (Sural Nerve) - MSCN, in the lower 1/3rd of the leg; CB-Communicating Branch, AT-Achilles Tendon, Lateral Sural Cutaneous Nerve (LSCN), CPN Common Peroneal Nerve, DPN-Deep Peroneal Nerve. **Figure 2B:** Schematic representation of the same.

Figure 3A: Dissection of the back of the leg showing the Medial Sural Cutaneous Nerve (MSCN) and the Lateral Sural Cutaneous Nerve (LSCN) descending separately and supplying the skin of the back of the leg and communicating in the upper 1/3rd of leg **Figure 3B:** Schematic representation of the same.

Figure 4A: Dissection of the back of the leg showing the Medial Sural Cutaneous Nerve (MSCN) and the Lateral Sural Cutaneous Nerve (LSCN), descending independently supplying the skin of the back of the leg and communicating in the lower 1/3rd of leg; CB-Communicating Branch, CPN- Common Peroneal Nerve.

Figure 4B: Schematic representation of the same.

fossa between the two heads of the gastrocnemius muscle. It pierced the deep fascia in the upper one-third of the leg and then descended in the superficial fascia of the back of the leg along the lateral side of the small saphenous vein to the back of lateral malleolus, supplying the skin of the lower half of the back of the leg entirely. In 39 specimens, the MSCN was joined by the LSCN or

sural communicating branch of Common Peroneal nerve and then descended to supply the lower half of the leg (Fig. 1).

Type 2: In one specimen, there was no LSCN from the common peroneal nerve. But the superficial peroneal nerve as it descended in the peroneal tunnel gave a communicating branch which joined the MSCN in the lower 1/3rd of the leg (Fig.

2).

Type 3: In three of the specimens, the MSCN and the LSCN descended on the back of the leg independently supplying the skin of the back of the leg but communicated in the upper 1/3rd of leg (Fig. 3).

Type 4: In two of the specimens, the MSCN and the LSCN descended on the back of the leg independently supplying

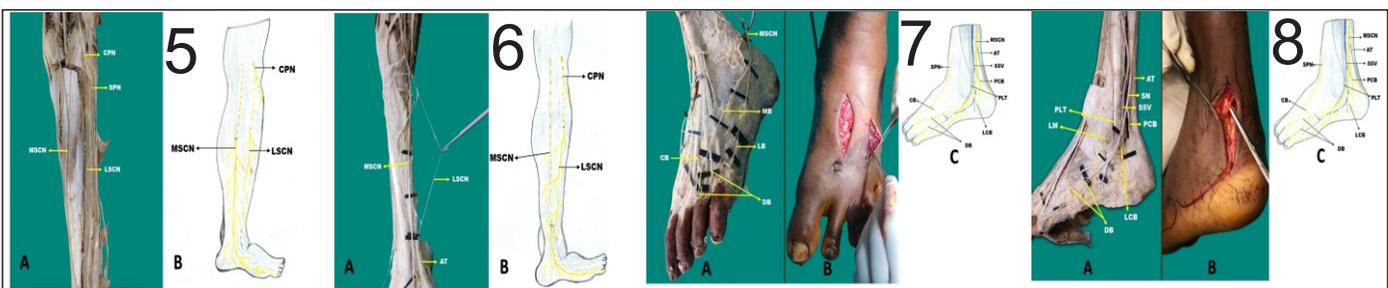


Figure 5A: Dissection of back of the leg showing the Medial Sural Cutaneous Nerve (MSCN) and the Lateral Sural Cutaneous Nerve (LSCN) descending independently supplying the skin of the back of the lower half of the leg without communicating with each other; CPN- Common Peroneal Nerve, Superficial Peroneal Nerve (SPN). **Figure 5B:** Schematic representation of the same.

Figure 6A: Dissection lateral aspect of the leg showing the Medial Sural Cutaneous Nerve (MSCN) supplying the lateral aspect of the heel, foot, and little toe without supplying the back of the lower half of the leg. Area of distribution of sural nerve was supplied by the Lateral Sural Cutaneous Nerve (LSCN); CPN- Common Peroneal Nerve, AT-Achilles Tendon. **Figure 6B:** Schematic representation of the same.

Figure 7A: Dissection of the lateral aspect of the ankle and dorsum of the foot showing the course and distribution of the sural nerve **Figure 7B:** Showing the incision given during surgical procedures in this region where the branches of the sural nerve may be at risk **Figure 7C:** Schematic representation of course and distribution of the sural nerve at lateral aspect of the ankle and dorsum of the foot; MB – Medial Branch, LB-Lateral Branch, CB-Communicating Branch, DB-Digital Branches, SPN-Superficial Peroneal Nerve, AT-Achilles Tendon, SSV-Short Saphenous Vein, LCB – Lateral Calcaneal Branch, PCB – Posterior Calcaneal Branch, PLT – Peroneus Longus Tendon.

Figure 8A: Dissection of the lateral aspect of the leg, ankle, and foot showing the course and distribution of the sural nerve **Figure 8B:** Showing the retromalleolar incision given during surgical procedures in this region where the sural nerve may be at risk **Figure 8C:** Schematic representation of course and distribution of the sural nerve on the lateral aspect of the leg, ankle and foot; SN – Sural Nerve, MSCN - Medial Sural Cutaneous Nerve, CB-Communicating Branch, DB-Digital Branches, SPN-Superficial Peroneal Nerve, AT-Achilles Tendon, SSV-Short Saphenous Vein, LCB – Lateral Calcaneal Branch, PCB – Posterior Calcaneal Branch, PLT – Peroneus Longus Tendon, LM – Lateral Malleolus.

Table 1: Shows the comparison of the studies of various pattern of sural nerve formation. MSCN-Medial Sural Cutaneous Nerve, LSCN-Lateral Sural Cutaneous Nerve.

Authors	Year	Total number of limbs studied	Sural nerve Formation				
			MSCN + LSCN	MSCN continued as sural nerve (LSCN absent)	Separate course of MSCN & LSCN	Absent MSCN	Absent LSCN
P.Mahakkanukrauh et al [10]	2002	152	67%	32%	-	-	-
iKiZ ZA et al [15]	2005	30	70%	-	7%	7%	17%
Pyun SB et al [18]	2008	26	77%	15%	8%	-	-
Kavyashree et al [6]	2013	50	72%	28%	-	-	28%
Awari P et al [2]	2017	50	60%	40%	40%	0	0
Our study	2018	50	78%	2%	20%	0	2%

the skin of the back of the leg but communicated in the lower 1/3rd of leg (Fig. 4).

Type 5: In four of the specimens, the MSCN and the LSCN descended on the back of the leg independently supplying the skin of the back of the lower half of the leg without communicating with each other (Fig. 5).

Type 6: In one of the specimen, the MSCN pierced the deep fascia near the lower end of the fibula and proceeded to supply the lateral aspect of the heel, foot, and little toe without supplying the back of the lower half of the leg, and its area of distribution was supplied by the LSCN (Fig. 6).

In the Foot:

In the majority, behind and below the lateral malleolus, the sural nerve gives cutaneous branches to the lateral side of

the heel and runs along the lateral aspect of the foot and little toe giving branches to the skin along its course. On the dorsum of the foot, it communicates with the branches of the superficial peroneal nerve.

Type 1: In two specimens, the sural nerve in addition to supplying the lateral side of the foot and little toe also supplied adjacent sides of 4th and 5th toes, which is normally supplied by superficial peroneal nerve (Fig. 7).

Type 2: In two specimens, sural nerve gave large posterior calcaneal branch supplying the skin and soft tissues of the back of the heel behind and below the lateral malleolus. It also gave a lateral calcaneal branch below the lateral malleolus to supply the lateral aspect of the heel. Further, in its course, it gave two branches medial and lateral, near

The lateral branch progressed along the lateral aspect of the foot and little toe providing cutaneous branches along its course in the dorsum aspect of the foot. The medial branch progressed forwards and medially providing cutaneous branches to supply the lateral 1/3 of the dorsum of the foot. Then it divided into two branches which supplied adjacent sides of 3rd and 4th & 4th and 5th toes. The medial branch communicated with the branch of the superficial peroneal nerve that supplied the 2nd inter digital cleft (Fig 8).

Discussion

Uluutku et al. reported the level of sural nerve formation in the back of the leg was more commonly middle 3rd in both sexes. The lower 3rd of the leg was the more frequent formation of the nerve in the case of females [4]. In a study by P. Mahakkanukrauh et al, Kavyashree et al., in 6% of limbs, MSCN, and LSCN joined in the upper 1/3rd of the back of leg [5,6]. In our study the sural nerve formed at the upper 1/3rd of leg accounting for 78% of the specimens to form the sural nerve trunk (39 limbs). In the rest of the specimens, they were independently running on the back of the leg to supply the skin but communicated with each other in the upper and lower 1/3rd of the leg.

Table 2: Shows the comparison of studies on the site of sural nerve formation.

Authors	Year	Total number of limbs studied	Sural nerve Formation		
			Upper 1/3rd of the leg	Middle 1/3rd of the leg	Lower 1/3rd of the leg
P.Mahakkanukrauh et al [10]	2002	152	6%	2%	66.7%
iKiZ ZA et al [15]	2005	30	20%	40%	10%
Pyun SB et al [18]	2008	26	-	35%	42.3%
Kavyashree et al [6]	2013	50	6%	33%	58.3%
Awari P et al [2]	2017	50	4%	22%	34%
Our study	2018	50	78%	-	-

There was one specimen (2%) in which LSCN was absent, and therefore skin of the back of the leg was solely supplied by MSCN. In this particular case, MSCN received a communicating branch from the superficial peroneal nerve at 12 cm from the tip of the lateral malleoli. This particular variation is unique, and the knowledge of this can be helpful while operating around the leg, especially during harvesting fibula as a cortical graft and in open reduction of high fibula (suprasyndesmotomic) fractures.

In 6.7% of 60 limbs studied in Brazil, it was observed that the sural nerve had intramuscular (gastrocnemius muscle) course and in one of the specimen, it was found bilaterally. It was also observed that MSCN and the LSCN did not unite in the majority of cases [7]. Another cadaveric study from turkey also showed that in 6.7% cases MSCN and LSCN had a separate course in the back of the leg [8]. In our study, in 20% of the specimens, MSCN and LSCN descended independently supplying the skin of the back of the distal half of the leg, out of which in 10% of the limbs, they did not communicate at all. But in 6% (3 limbs) they communicated in the upper 1/3rd of the limb and 4% (2 limbs) they communicated in the lower 1/3rd of the leg.

In 10% of the limbs in our study, the MSCN and LSCN had a separate course individually without communication with each other. An anatomical study was done by Preethi et al [2] also explained the similar variation in 40% of limbs dissected. This anatomical variation has a surgical significance of using the LSCN alone as the nerve graft instead of the conventional sural nerve, when limited nerve graft length is the requirement, thereby preserving the cutaneous supply provided by the MSCN to the leg. A preoperative ultrasound screening of the limb will be valuable

in such circumstances.

In our study, in 2%, the MSCN did not give any branches to supply the skin on the back of the leg, and instead, this area was supplied by LSCN alone. Hence the distribution of sural nerve was restricted to hind foot, lateral aspect of the dorsum of the foot and lateral two and a half toes.

The sural nerve courses along the lateral margin of Achilles tendon to which the nerve is very closely related at a level of 7 cm above the apex of the fibular malleolus. In the hind foot, the nerve courses 1.4 cm behind and 1.4 cm below the apex of fibular malleolus [1]. In our study the sural nerve coursed close to the Achilles tendon at 9cm above the tip of lateral malleolus but as it descended about 1 cm behind the lateral malleolus it gave off a posterior calcaneal branch and then further down near the tip of the lateral malleolus it furnishes a lateral calcaneal branch (Fig. 8). Crossing of sural nerve in relation to Achilles tendon is clinically significant as this anatomical knowledge helps in appropriate placement of the incision during percutaneous tendon repairs. The reported chances of injury to sural nerve and sural nerve related complications accounts for 18% during this surgery [9,10,11]. The sural nerve terminated in the foot by dividing into two branches near the cuboid bone, medial and lateral. The medial terminal branch communicated with the branch of superficial peroneal nerve supplying 2nd interdigital cleft, then it divided into two branches which supplied skin of lateral 1/3rd of dorsum of foot and skin of 3rd and 4th inter digital clefts. The lateral branch progressed along the outer aspect of the foot and fifth toe, providing branches to supply the skin and connective tissue along its course on the lateral aspect of the foot and little toe (Fig.7). In the surgical approach to Lisfranc fracture dislocation injuries, between 4th and 5th metatarsals, knowledge of above variation has got

clinical significance to avoid iatrogenic injury to sural nerve terminal branches thereby preventing potential complication of a painful neuroma formation (Fig. 8).

Conclusion

The Foot and Ankle surgeons must be aware of the normal anatomy of the sural nerve and its numerous variations to prevent iatrogenic damage especially during the posterolateral approach of the leg and the lateral approach of the foot.

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In our study, 4% (Two specimens) showed termination of sural nerve supplying the skin of adjacent sides of the third, fourth and fifth toes in addition to the lateral side of 5th toe.

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