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Anatomy of the Sural Nerve Related to Calcaneal Tendon, Intermalleolar Line and Small Saphenous Vein

Anatomía del Nervio Sural en Relación con el Tendón Calcáneo, la Línea Intermaleolar y la Vena Safena Parva

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SUMMARY: Sural nerve (SN) courses from the posterior aspect of leg to the lateral side of ankle and foot. Anatomy of the SN is of clinical importance due to its involvement in nerve biopsy, nerve graft harvesting including injuries during calcaneal tendon repair. Despite substantial knowledge in the literature, more easily located landmarks and data regarding the symmetry are still needed. Ninety-eight lower extremities from 31 males and 18 females were dissected in this study. The SN originated from the union between the medial and lateral sural cutaneous nerves in 52.0 % of the legs. The distance from the union point to the intermalleolar line (IML) was 16.3±8.4 (SD) cm. The ratio of this distance to the fibular length (apex of head to lateral malleolus or LM) was 0.47±0.23 cm. In 84.7 % of the legs, the SN initially coursed medial to and then crossed the lateral border of calcaneal tendon at the distance of 8.4±2.1 cm above the IML. The ratio to the fibular length was 0.25±0.06 cm. At the level of IML, the SN was posterior to the most prominent part of the LM in 95.9 % of the legs with the distance of 2.6±0.5 cm. At the closest point, the SN was lateral to the small saphenous vein in 74.5 % of the legs and the distance from this point to the IML was 10.6±4.7 cm. The ratio to the fibular length was 0.31±0.14 cm. Side difference or asymmetry was observed in a substantial number of specimens. These data are crucial for not only localizing the SN during biopsy and graft harvesting but also avoiding the nerve injury during relevant surgical procedures.

KEY WORDS: Sural nerve; Anatomy; Calcaneal tendon; Intermalleolar line; Small saphenous vein.

INTRODUCTION

Sural nerve (SN) courses from the posterior aspect of leg to the lateral side of ankle and foot. Its anatomy is of clinical importance since the SN is frequently used for biopsy and nerve graft to diagnose neuropathies and repair nerve injuries, respectively (Matsuyama *et al*., 2000; Mikell *et al*., 2013). In addition, the SN can be injured during surgery of varicosed small saphenous vein (SSV) (Mondelli *et al*., 1997; Kerver *et al*., 2012) and repair of calcaneal tendon rupture (Molloy & Wood, 2009).

A number of studies have been done to clarify the anatomy of SN in relation to adjacent structures. The course of SN related to the calcaneal tendon was examined (Apaydin *et al*., 2009; Eid & Hegazy, 2011). Furthermore, the relation to the SSV was investigated (Eid & Hegazy). At the ankle, the position of SN referred to the lateral malleolus (LM) was studied (Lawrence & Botte, 1994; Mahakkanukrauh & Chomsung, 2002; Aktan Ikiz *et al*., 2005). However, the reference points used in the previous studies are difficult to locate in the living subjects and the comparison with the bone length was not taken into account. Moreover, the proper comparison between sides was lacking. Therefore, this study employed the intermalleolar line (IML) and ratio of fibular length to describe the SN anatomy in relation to the calcaneal tendon, LM and the SSV on both sides. Our data is useful for locating the SN and avoiding the nerve injury during relevant procedures.

MATERIAL AND METHOD

Ninety-eight lower extremities from 49 formalin-fixed cadavers (31 males and 18 females) were included with an approval from the institutional ethics committee. The average age of cadavers was 71.3±15.3 (SD) years (20–93 years).

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The popliteal fossa including the posterior and lateral aspects of leg and ankle were carefully dissected to expose the SN, medial sural cutaneous nerve (MSCN), lateral sural cutaneous nerve (LSCN) and SSV with their anatomical positions preserved with pins. The most prominent points of the medial and lateral malleoli were identified and the string passing these two points was used to indicate the intermalleolar line (IML). The origin of SN was examined and the contribution from the MSCN and LSCN was noted. More distally, the course of SN related to the lateral margin of calcaneal tendon, the most prominent part or tip of LM and SSV was studied.

To obtain quantitative data, a digital caliper was used to measure the following distances (Fig. 1): vertical distance from the origin of SN to the IML, vertical distance from the intersection point between the SN and the lateral margin of calcaneal tendon to the IML, horizontal distance between the SN and LM, vertical distance from the closest point between the SN and SSV to the IML. Furthermore, the vertical distances were compared with the fibular length (distance from the apex of head to the LM). Student's t test was carried out to detect any significant differences in the above data between sides. $p < 0.05$ was considered significant.

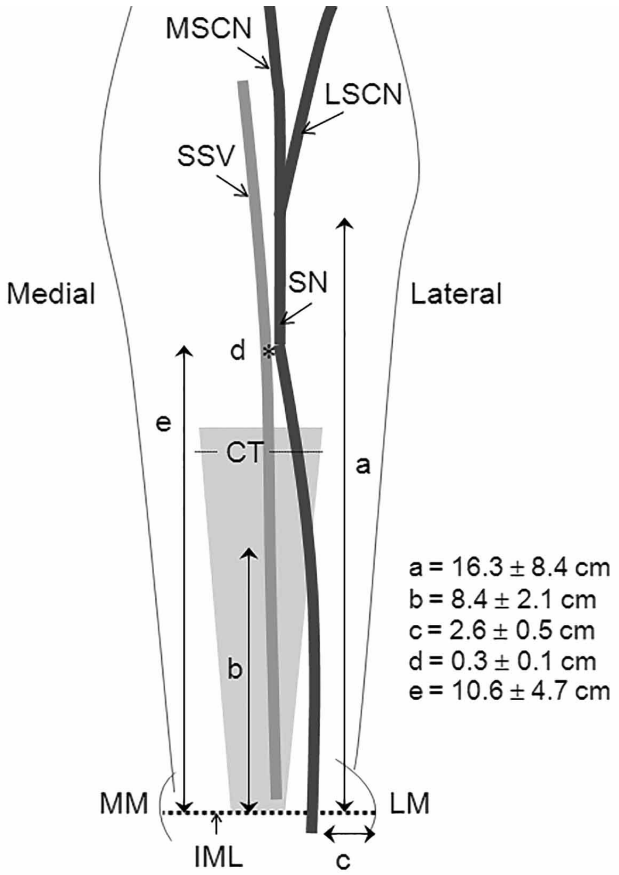

Fig. 1. Measurements regarding the anatomy of sural nerve (SN) done in this study. The posterior aspect of right leg is shown. The following distances were measured: the origin of SN to the IML (a), the crossing point between the SN and lateral border of CT to the IML (b), the SN to the LM at the level of IML (c), the SN to the SSV at the closest point (d), the closest point between the SN and the SSV to the IML (e). MSCN medial sural cutaneous nerve, LSCN lateral sural cutaneous nerve, SSV small saphenous vein, CT calcaneal tendon, IML intermalleolar line, MM medial malleolus, LM lateral malleolus. The means ± SD of these distances are also shown.

RESULTS

The SN originated from the union between the MSCN and LSCN in 51 legs (52.0 %) (Fig. 2). The distance from the union point to the IML was 16.3±8.4 (SD) cm (2.4–47.0 cm) (Table I). The ratio of this distance to the fibular length was 0.47±0.23 (0.07–1.12 cm). In 39 (39.8 %) and 8 (8.2 %) legs, the SN was derived solely from the MSCN or LSCN, respectively. Within these 47 specimens, absence of the MSCN or LSCN was noted in 1 (1.0 %) and 3 (3.1 %) legs, respectively (Fig. 2). Side difference or asymmetry in the origin of SN was observed in 23 cadavers (46.9 %).

Regarding the relationship with the lateral margin of

Table I. Measurement data of sural nerve related to important landmarks.

Measurement	Distance (cm) (Range)		
	Right	Left	Total
Union of MSCN & LSCN - IML	16.5±6.9	16.0±10.1	16.3±8.4 (2.4–47.0)
Crossing of SN & LBT - IML	8.6±1.7	8.1±2.4	8.4±2.1 (1.4–13.6)
SN - LM at IML	2.6±0.5	2.6±0.6	2.6±0.5 (1.2–3.9)
SN - SSV at the closest point	0.3±0.1	0.3±0.1	0.3±0.1 (0.1–0.5)
Closest point of SN & SSV - IML	12.0±5.4	9.2±3.5*	10.6±4.7 (1.4–34.7)

Data are Means ± SD, * $p < 0.05$ vs. right. SN= sural nerve, MSCN= medial sural cutaneous nerve, LSCN= lateral sural cutaneous nerve, IML= intermalleolar line, LBT= lateral border of calcaneal tendon, LM= lateral malleolus, SSV= small saphenous vein.

the calcaneal tendon, the SN initially coursed medial to and then crossed the lateral margin of tendon in the majority of cases (83 legs, 84.7 %). The distance from the crossing point to the IML was 8.4±2.1 cm (1.4–13.6 cm) (Table I). The ratio of this distance to the fibular length was 0.25±0.06 (0.04–0.39 cm). In 15 specimens, the SN was always lateral to the lateral margin of tendon. Asymmetry in the course of SN related to the lateral margin of calcaneal tendon was observed in 11 cases (22.5 %).

At the level of IML, the SN was posterior to the most prominent part of the LM in most specimens (94 legs, 95.9 %). The horizontal distance from the nerve to the LM was 2.6±0.5 cm (1.2–3.9 cm) (Table I). In 4 legs (4.1 %), the nerve was in contact with the tip of LM.

At the closest point between the SN and SSV, the nerve was lateral to the vein in 73 legs (74.5 %). In the other legs, the nerve was medial to the vein. The distance between these two structures at the closest point was 0.3±0.1 cm (0.1–0.5 cm) (Table I). The distance from this point to the IML was 10.6 ± 4.7 cm (1.4-34.7). The ratio of this distance to the fibular length was 0.31±0.14 (0.04–1.06 cm). There were 13 legs that the course of SN related to the SSV was different between sides (26.5 %).

After comparing the measurement data between sides, a small but significant difference was observed in the distance from the closest point between the SN and SSV to the IML (Table I). Other distances or ratio were not significantly different between sides. Important measurement data are summarized in Figure 1.

DISCUSSION

This study showed that the SN originated from the union between the MSCN and LSCN in more than half of the legs. The previous studies have also shown that this type of origin was observed in the majority of cases (Ortigüela *et al.*, 1987; Mahakkanukrauh & Chomsung; Aktan Ikiz *et al.*; Pyun & Kwon, 2008; Riedl & Frey, 2013). The mean distance from this union point to the IML was 16.3 cm which was consistent with 18.3 cm to the LM reported in Riedl & Frey. The ratio to the fibular length was 0.47 cm, about mid-leg. Nevertheless, it should be borne in mind that the location of the union point in the leg was highly variable (Riedl & Frey). As for other types of origin, this and the above studies found that the direct continuation from the MSCN was the second most common. The direct continuation from the LSCN including absence of the MSCN or LSCN was present in this and other studies (Aktan Ikiz *et al.*; Riedl & Frey). Regarding the side difference, we found asymmetry in the origin of SN in 46.9 % of legs compared with 80.3 % in Mahakkanukrauh & Chomsung and about two-thirds in Riedl & Frey. These data indicate that although the union between the MSCN and LSCN to become the SN was seen in most cadavers, the variation and asymmetry were relatively high.

Fig. 2 Variations in the origin of sural nerve (SN): union of medial sural cutaneous nerve (MSCN) and lateral sural cutaneous nerve (LSCN) (A), Absence of MSCN (B), Absence of LSCN (C). SSV small saphenous vein, CT calcaneal tendon.

In relation to the lateral margin of the calcaneal tendon, our data showed that, in 84.7 % of legs, the SN changed its course from the medial to lateral sides. The

intersection point was 8.4 cm from the IML in average. Apaydin *et al*., reported that 95.5 % of specimens had the medial-to-lateral course of SN and the mean distance from the intersection point to the LM was 10.4 cm. Eid & Hegazy found that the SN crossed the lateral margin of calcaneal tendon in 50 % of legs. Our findings were consistent with those of the above studies. Furthermore, we also showed that the average ratio between the distance from the intersection point to the IML and the fibular length was 0.25 cm. This was approximately one-fourth of the length of fibula above the LM. Application of the IML as the landmark has an advantage since the malleoli can be easily palpated in most subjects. The comparison with the fibular length also takes the bone length which is variable among individuals into account. When considering the side difference, this study found asymmetry in the course of SN in 22.5 % of cases and no significant difference in any distance or ratio was observed. These findings were similar to the results of Apaydin *et al*. These data are important for avoiding nerve injury, especially during percutaneous repair of calcaneal tendon which can be associated with the SN injury (Cretnik *et al*., 2005). High variations among individuals should also be aware.

Regarding the relation to the LM, the SN was posterior to this landmark in most specimens which was consistent with other studies (Mahakkanukrauh & Chomsung; Aktan Ikiz *et al*.; Eid & Hegazy). The average distance from the SN to the tip of LM was 2.6 cm in this study. Aktan Ikiz *et al*. reported the distance of 1.3 cm. Another study obtained the mean distance of 1.4 cm (Lawrence & Botte). Aktan Ikiz *et al*. also observed that the SN was in contact with the tip of LM in 13.3 % of their specimens. The incidence of 4.1 % in this study was much lower. High variation among subjects was likely responsible for the different results among studies.

The closely related anatomy of the SN and SSV has been recognized. Our data showed that, at the closest point between the two structures, the nerve was lateral to the vein in 74.5 % of legs. Consistent with our findings, Eid & Hegazy reported that the SSV was medial to the SN in all legs. We found that the shortest distance between the SN and SSV was 0.3 cm in average compared with 0.4 cm in Eid & Hegazy. We also measured the distance from the closest point to the IML which was 10.6 cm in average. When compared with the fibular length, the average ratio was 0.31 or approximately one-third above the LM. The close position between the two structures in the lower leg was supported by Kerver *et al*. which found the distance of less than 5 mm in the lower two-thirds of legs in 90 % of specimens. Furthermore, the puncture site for endovenous surgery of the SSV above the distal leg was shown to reduce the risk of SN injury (Doganci *et al*., 2011). As for the side difference, 26.5 % of legs had asymmetry in the course of SN related to the SSV. Moreover, the distance from the closest point to the IML was significantly different between sides. Taken together, these data will be useful to reduce the incidence of nerve injury particularly during surgery of varicosed SSV in the distal leg.

In conclusion, this study examined the anatomy of sural nerve related to the lateral margin of calcaneal tendon, lateral malleolus and small saphenous vein. Employing the novel references, intermalleolar line and fibular length, we obtained both similar and different results to those of the previous studies. In addition, our findings also emphasize the high variation and asymmetry of the sural nerve anatomy. These data are important for not only avoiding the iatrogenic injury to the sural nerve but also locating the nerve during biopsy and graft harvesting.

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DANGINTAWAT, P.; HUANMANOP, T.; AGTHONG, S. & CHENTANEZ, V. Anatomía del nervio sural en relación con el tendón calcáneo, la línea intermaleolar y la vena safena parva. *Int. J. Morphol., 34(1)*:380-384, 2016.

RESUMEN: El nervio sural (NS) transcurre por la región posterior de la pierna, el tobillo y el pie. La anatomía del NS es de importancia clínica durante la realización de una biopsia, el desarrollo de injerto de nervio, incluyendo lesiones del nervio durante la reparación del tendón calcáneo. A pesar del conocimiento sustancial en la literatura, aún se necesitan puntos de referencia más fáciles de localizar e información sobre la simetría. Noventa y ocho miembros inferiores de 31 hombres y 18 mujeres fueron disecados. El NS se originó a partir de la unión entre los nervios cutáneo sural medial y cutáneo sural lateral en el 52,0 % de las piernas. La distancia desde el punto de unión a la línea intermaleolar (IML) fue de 16,3±8,4 (SD) cm. La relación de esta distancia a la longitud de la fíbula (vértice de la cabeza al maléolo lateral o LM) fue de 0,47±0,23 cm. En el 84,7 % de las piernas, el NS se ubicó inicialmente medial y luego cruzó el margen lateral del tendón calcáneo a una distancia de 8,4±2,1 cm proximal a la IML. La relación de longitud de la fíbula fue de 0,25±0,06 cm. A nivel de la IML, el NS se localizaba posterior a la parte más prominente de la LM en el 95,9 % de las piernas, con una distancia de 2,6±0,5 cm. En el punto más cercano, el NS se localizaba lateral a la vena safena parva en 74,5 % de las piernas y la distancia desde este punto hasta la IML fue de 10,6±4,7 cm. La relación de longitud de la fíbula fue

0,31±0,14 cm. La diferencia entre los lados o asimetría se observó en un número considerable de ejemplares. Estos datos son esenciales no sólo para localizar el NS durante la biopsia y la realización del injerto sino también para evitar la lesión del nervio durante procedimientos quirúrgicos relevantes.

PALABRAS CLAVE: Nervio sural; Anatomía; Tendón calcáneo; Línea intermaleolar; Vena safena menor.

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