Int. J. Morphol.,
23(2):163-170, 2005.

Anatomical and Biometric Aspects of the Cutaneous Distribution of the Superficial Fibular Nerve

Aspectos Anatómicos y Biométricos de la Distribución Cutánea del Nervio Fibular Superficial

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GABRIELLI, C.; FROEHNER, JR., I. & BRAGA, M. T. T. Anatomical and biometric aspects of the cutaneous distribution of the superficial fibular nerve. ***Int. J. Morphol., 23(2)***:163-170, 2005.

SUMMARY: The objective of this research was to study the cutaneous branching of the superficial fibular nerve (SFN), with a topographic and biometric focus, aiming to provide further anatomical details for foot and ankle surgery in general. There were analyzed 30 right and left lower limbs of 15 corpses of male adult Brazilian individuals. The cutaneous branching of the nerve was dissected and measurements taken with a tape measure and digital caliper. The nerve emerged at the surface as a single trunk in 66.7% and divided into two branches in 33.3% of the cases. When a single trunk emerged, it appeared at the level of the third distal of the leg in 75%, at the boundary between the middle and distal thirds in 20%, and, in the middle third in 5%. When divided, in most cases (60%), the two branches had the same topography, in general, in the distal third of the leg. The average width of the nerve, at its emergence, when single, was 3.1 ± 0.8 mm, when divided, one of its branches, the medial dorsal cutaneous nerve (MDCn) of the foot, measured 2.4 ± 0.9 mm, and the other, the intermediate dorsal cutaneous nerve (IDCn) of the foot 2.1 ± 0.6 mm. The MDCn communicated with the deep fibular nerve in 53.3%, and the IDCn with the sural nerve in 33.3%. In its distribution in the dorsum of the foot, the MDCn was related mainly with the first metatarsal bone and the first and second interosseous spaces, and the IDCn, in general, with the fourth metatarsal bone and the third and fourth interosseous spaces. There are important variations in the emergence and cutaneous branching of the SFN, which must be known in order to avoid iatrogenic injury during surgical procedures on the foot and ankle.

KEY WORDS: Anatomy; Leg; Foot; Nerves; Superficial fibular nerve.

INTRODUCTION

The human foot and ankle are important for sustaining body weight, maintaining biped posture, locomotion and equilibrium, and for such purposes, it is necessary that their articular, vascular and nervous integrities are maintained.

In this respect, foot artery reconstruction surgery has often been carried out, through bypasses (Dorweiler et al., 2002), reconstructive plastic surgery on the dorsum of the foot, through cutaneous flaps (Onishi & Maruyama, 1996), as well as ankle arthroscopy (Saito & Kikuchi, 1998; Takao *et al.,* 1998). Such procedures, in dealing with deeper anatomical elements, must preserve the more superficial structures, including cutaneous nerves; since their lesion would result in anaesthetic areas.

The cutaneous nerve which covers the greater area of the dorsum of the foot is the superficial fibular nerve, whose sensitive component emerges at the surface in the lower region of the leg and is distributed through the foot. Anatomical descriptions of this nerve in textbooks (Testut & Latarjet, 1945; Moore & Dalley, 2001) as well as in specific researches (Kosinski, 1926; Blair & Botte, 1994; Canovas *et al.,* 1996) indicate the great variability regarding its course in the leg, its distribution in the dorsum of the foot and its communications with other nerves.

With the advent of microsurgery, the placement of a nerve graft has become possible in order to correct a discontinuity of damaged nerves and due to the anatomical features which it presents, the superficial fibular nerve may be used in this procedure (Sommerschild, 1981; Buntic *et al.*, 2002).

Thus, we proposed to study in detail, the biometric and topographic characteristics of the superficial fibular nerve from its emergence to its branching and distribution in the skin of the dorsum of the foot.

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MATERIAL AND METHOD

For this study 30 lower limbs, right and left, were utilized, from 15 corpses of male adult Brazilian individuals, of different races, conserved in a solution of 10% formalin, from the Department of Morphological Sciences of the Universidade Federal de Santa Catarina - Brazil.

The superficial fibular nerve (SFN) and its cutaneous distribution (after perforating the crural fascia) were dissected in the anterolateral region of the leg and the dorsum of the foot, observing their topographies in relation to the anterior margin of the tibia, intermalleolar line and metatarsal bones, as well as possible communications with the deep fibular and the sural nerves, in the foot.

With the aid of a tape measure and a Starrett® digital caliper, the following measurements were then collected:

a) leg length (from the medial condyle of the tibia to the lower extremity of the medial malleolus – Bastos-de-Ávila, 1958), in cm;

b) distance from the emergence of the SFN (or its branches) to the medial malleolus, in cm;

c) distance from the emergence of the SFN (or its branches) to the anterior margin of the tibia, in mm;

d) width of SFN (or it branches) at the level of its emergence, in mm;

e) distance from the SFN division into the medial dorsal cutaneous nerve (MDCn) and intermediate dorsal cutaneous nerve (IDCn) of the foot to the intermalleolar line, in cm;

f) distance of the branches (MDCn and IDCn) to the anterior margin of the tibia, at the level of the ankle, in mm.

Afterwards, the "a" measurement was divided by three, in order to determine the measurement of each third of the leg (denominated as proximal, middle and distal). Comparing this data with the value obtained for "b", it was determined in which third of the leg the emergence of the nerve occurred, or whether at the boundary between one third and another. For a more precise topography, each third was subdivided into three parts (proximal, middle and distal) and the values were again compared.

All other measured values obtained were tabulated and treated statistically, for the obtention of averages and standard deviations.

RESULTS

Characteristics of SFN emergence: The SFN emerged at the surface as a single trunk in 20/30 cases (66.7%), 8 to the right and 12 to the left, with bilateral incidence in 8/15 individuals (53.3%) (Fig. 1). In the remaining 10 cases (33.3%), the SFN divided before perforating the crural fascia and the MDCn and IDCn emerged separately (Fig. 2); in 7 samples to the right, 3 to the left and bilaterally in 3 individuals (20%).

Fig. 1. Right lower limb – anterior view. The superficial fibular nerve (1) emerges as a single trunk. There is a communicating branch (arrow) between the medial dorsal cutaneous nerve of the foot (2) and the deep fibular nerve (3).

Topography of the SFN emergence: The topography of the SFN emergence as a single trunk (in relation to the thirds and parts of the leg) is illustrated in Fig. 3.

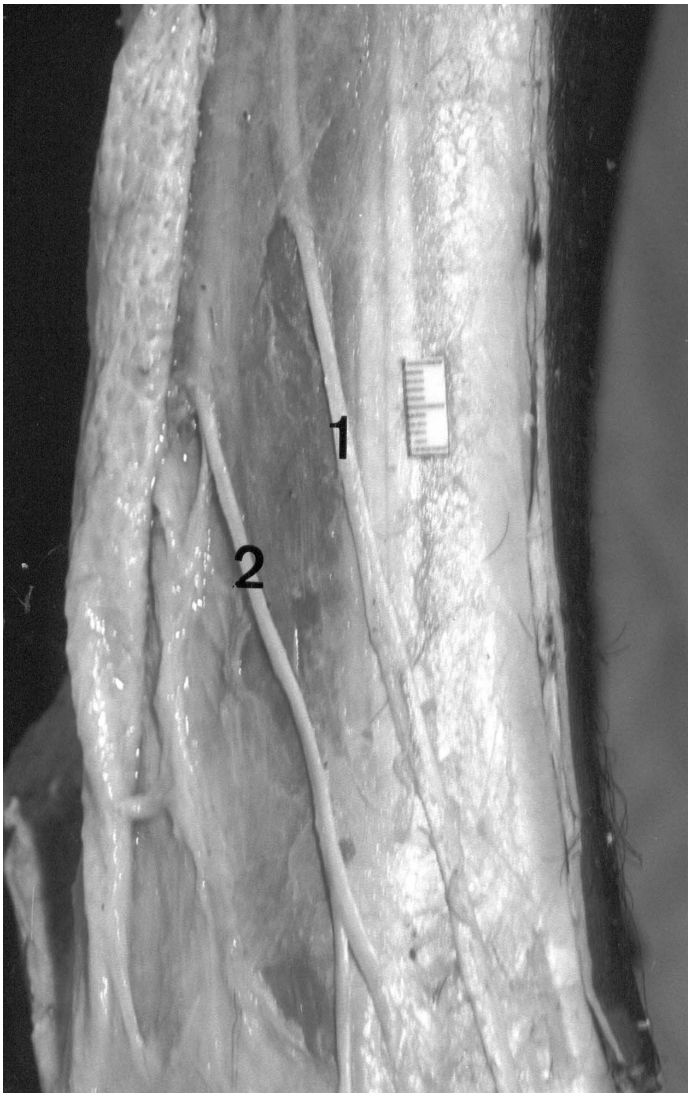

Fig. 2. Right lower limb – anterolateral view of the leg. The superficial fibular nerve emerged already divided into the medial (1) and the intermediate (2) dorsal cutaneous nerves of the foot.

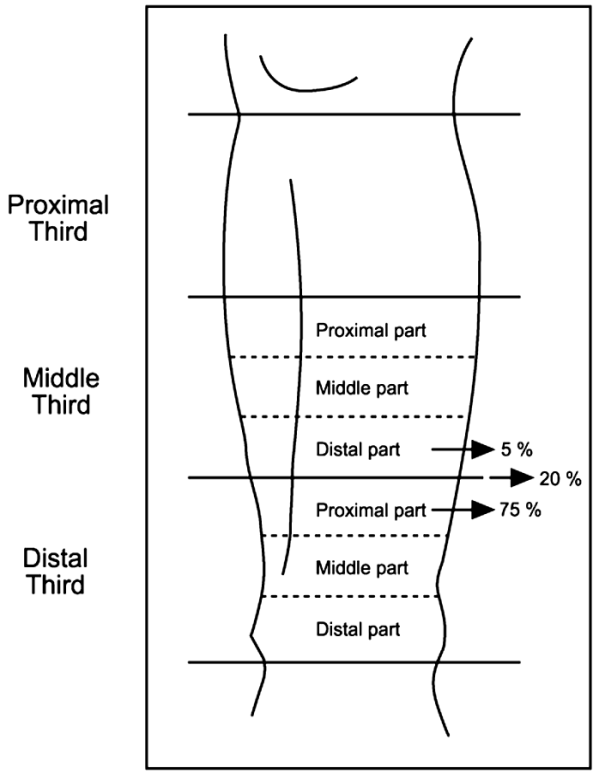

Fig. 3. Division of the leg into proximal, middle and distal thirds and their respective parts, and, the level of emergence of the superficial fibular nerve as a single trunk.

Width of nerves at the level of emergence: When the SFN emerged as a single trunk, it had an average width of 3.05 ± 0.8 mm. When its branches appeared separated, the MDCn had an average width of 2.4 ± 0.9 mm, and the IDCn of 2.10 ± 0.6 mm.

When the MDCn and IDCn emerged separately, it was observed only in which third of the leg this occurred. In 6/10 cases (60%), both the nerves had the same topography: in 5 of them, they appeared in the distal third of the leg and in 1, at the boundary between the middle and distal thirds. In the 4 remaining samples, there was no agreement: the MDCn emerged in the middle third in three cases and in the proximal in 1; the IDCn always appeared in the distal third.

As regards the distance between the emergence of the nerves to the anterior margin of the tibia, the following measurements were obtained: 36.5 ± 4.5 mm (SFN as a single trunk); 37.0 ± 4.3 mm (MDCn) and 41.5 ± 6.6 mm (IDCn).

Height of the SFN division in the leg: This measurement was taken in cases where the SFN perforated the crural fascia as a single trunk and later divided into the MDCn and IDCn, which occurred in 17/20 cases; in the 3 remaining, the IDCn was considered absent or atrophic, terminating at the level of the ankle, and its area of distribution in the dorsum of the foot was substituted by the sural nerve. The division of the SFN occurred proximal to the intermalleolar line, at an average of 6.87 ± 2.1 cm.

Distance from the MDCn and IDCn to the anterior margin of the tibia at the level of the ankle: On crossing the ankle joint, the MDCn had an average distance from the anterior margin of the tibia of 11.5 ± 4.3 mm, while that for the IDCn (or its most medial fine branch) was 33.4 ± 5.9 mm from the referred bone margin.

Communicating branches between the SFN and the Deep Fibular (DFN) and Sural (SN) nerves: In the dorsum of the foot, communications between the MDCn and the cutaneous branch of the DFN (at the level of the first interosseous space) were observed in 16/30 cases (53.3%) (Fig.1); while communications between the IDCn and the SN were found in 9/27 cases (33.3%) (Fig. 4).

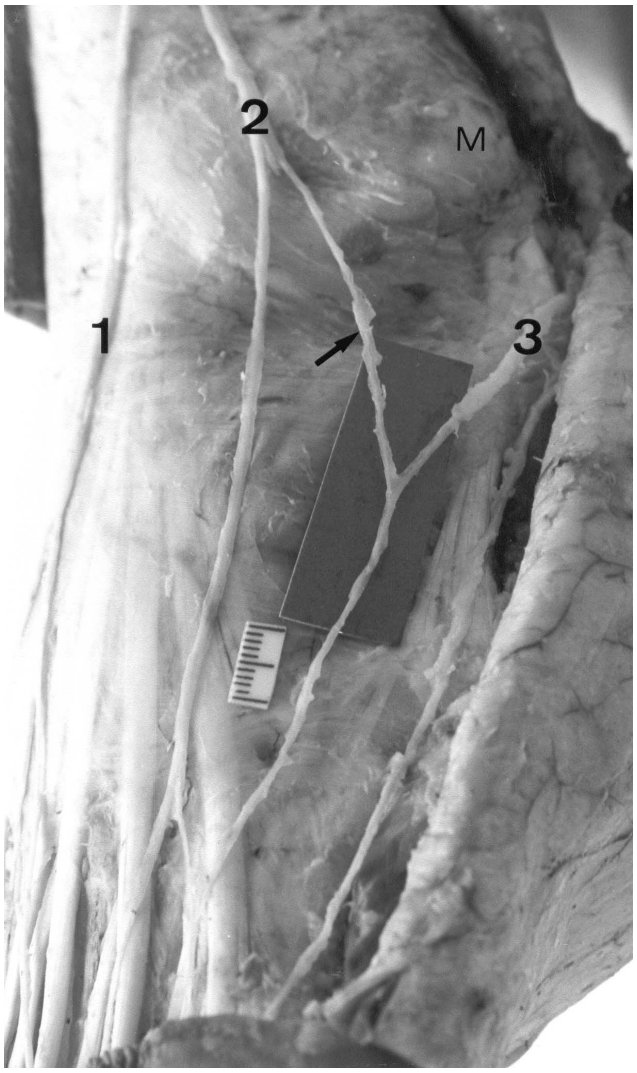

Fig. 4. Left foot and ankle - lateral view: (M) lateral malleolus; (1) medial dorsal cutaneous nerve of the foot. There is a communicating branch (arrow) between the intermediate dorsal cutaneous nerve of the foot (2) and the sural nerve (3).

Topography of the SFN branches in the dorsum of the foot: The distribution (terminal branching) of the MDCn was related to the first and second metatarsal bones and the first interosseous (IO) spaces, described in decreasing order of frequency (Fig. 5):

a) medial and on first metatarsal bone, first and second IO spaces: 13 cases (43.3%);

b) medial and on first metatarsal bone and second IO space: 6 (20%);

c) medial to first metatarsal bone, on second metatarsal bone and second IO space: 3 (10%);

d) medial to first metatarsal bone and first IO space: 3 (10%);
e) medial to first metatarsal bone and second IO space: 3 (10%);

f) medial to first metatarsal bone, first IO space and on second metatarsal bone: 2 (6.6%).

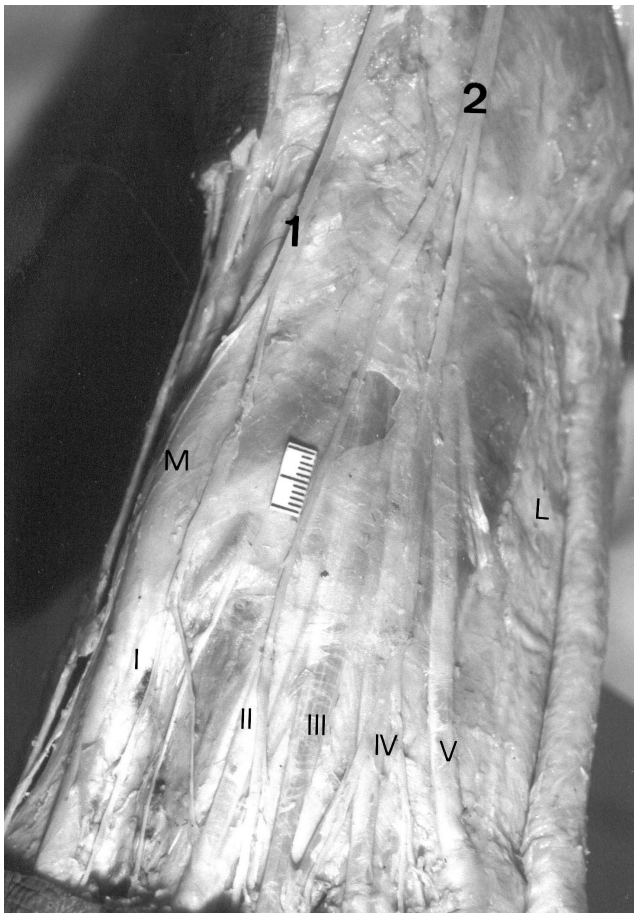

Fig. 5. Left dorsum of the foot: (M) medial and (L) lateral parts of the foot. The distribution and topography of the medial (1) and the intermediate (2) dorsal cutaneous nerves of the foot can be observed. I to V: metatarsal bones.

The distribution of the IDCn was related to the more lateral metatarsal bones and interosseous spaces, as follows (Fig. 5):

a) on fourth metatarsal bone, third and fourth IO spaces: 15 samples (55.5%);

b) on fourth and fifth metatarsal bones, third and fourth IO spaces: 5 (18.5%);

c) on fourth and fifth metatarsal bones, second, third and fourth IO spaces: 2 (7.4%);

d) on fourth metatarsal bone, second, third and fourth IO spaces: 2 (7.4%);

e) on fourth metatarsal bone and fourth IO space: 1 (3.7%);
f) on fifth metatarsal bone: 1 (3.7%);

g) on fourth and fifth metatarsal bones, third and fourth IO spaces and lateral to fifth metatarsal bone: 1 (3.7%).

DISCUSSION

The emergence of the SFN at the surface, through the crural fascia, occurred in two forms: in most cases in our series (66.7%) the nerve emerged as a single trunk and in the minority (33.3%) the branched divisions (MDCn and IDCn) appeared independently. Certain anatomy textbooks also consider the emergence of the SFN as a single trunk, and they do not mention the possibility for it to emerge divided (Testut & Latarjet; Goss, 1988). On analyzing specific researches on the theme, it was verified that our findings agree with the fact that, in most cases, the SFN perforates the crural fascia as a single trunk, as with 65% of 68 legs mentioned by Solomon *et al.* (2001), 72% of 25 lower limbs (Blair & Botte), 74.7% of 118 legs (Kosinski), 93% of 104 samples (Saito & Kikuchi) and 96.7% of 30 cases (Canovas *et al.*).

On the other hand, despite being the minority, the fact that the SFN emerges divided should not be discounted, since it represents around one third of the cases studied, not only in our series but also in other researches, 28% and 35% respectively (Blair & Botte; Solomon *et al.*) and this has surgical implications. This variation in the height of the SFN division should be taken into account when one of its branches may be utilized in nerve grafting (Buntic et al.) or during the placement of bone fixation plates following a fibular fracture, in order to not damage the nerve (Blair & Botte).

Regarding the topography of the SFN emergence as a single trunk, it was found in our series that, in most cases (75%) it emerged in the distal third of the leg, in agreement with that described by many authors (Testut & Latarjet; Bruni, 1948; Goss; Latarjet & Ruiz-Liard, 1993; Moore & Dalley). In decreasing order of frequency, we found its emergence at the boundary between the middle and distal thirds (20%), as described by others (Healey & Seybold, 1972; Sunderland, 1985). On the other hand, it was observed in absolute values that the distance between the emergence of the nerve and certain points of reference (the ankle or the distal tip of the lateral malleolus) varied between 9 and 12 cm (Kosinski; Blair & Botte; Canovas *et al.*; Solomon *et al.*).

On dividing the thirds of the leg into the proximal, middle and distal parts, it was found that in all cases in which the nerve emerged in the distal third, it did so in its proximal part, and when it appeared in the middle third, it was in its distal part, and we can therefore affirm that, when the SFN emerges single, it does so in the proximity of the boundary between middle and distal thirds of the leg. This is an important topographical point, which facilitates the localization and dissection of this nerve, preventing it from being damaged during various procedures carried out on the fibula (Solomon *et al.*), as well as its utilization in nerve grafting (Sommerschild; Buntic *et al.*)

On analyzing also the topography of the emergence of the SFN branches, when it appeared already divided into the MDCn and IDCn, we found that in most cases (60%) both had the same topography, either in the distal third of the leg or at the boundary between this and the middle third. Other researchers report the distances found between the emergence of each branch and the lateral malleolus: for the MDCn the measurements vary between 7.3 and 12.7 cm and for the IDCn between 4.7 and 9.2 cm (Kosinski; Blair & Botte; Solomon *et al.*).

Also, in relation to the topography of the SFN emergence (as a single trunk or divided), we studied the distance between the referred nerve emergence and the anterior margin of the tibia; which in our series varied between approximately 36 and 42 mm. The authors consulted did not make reference to this bone margin as a point of reference; however, Blair & Botte observed the IDCn emerging behind the fibula in 16% of cases, a situation not found in our study.

The width of the SFN (or that of its branches) was measured at the level of its emergence: when a single trunk the SFN had an average width of 3.05 mm and when divided the MDCn measured around 2.4 mm and the IDCn, 2.1 mm. This nerve width facilitates its visualization and dissection with the naked eye, allowing it to be isolated and free from damage during the various surgical procedures carried out on the leg, or to be used in nerve grafting (Sommerschild; Buntic *et al.*).

After the SFN perforates the crural fascia, it divides into the MDCn and the IDCn at a variable height, which was measured in 17 cases in our series, it being observed that in 10, the nerve emerged already divided and in another 3, the IDCn was considered absent or atrophic, since it did not reach the dorsum of the foot, a situation also found by other authors, such as 10% of 30 legs (Canovas *et al.*), 13.7% of 118 (Kosinski) and 35% of 68 lower limbs (Solomon *et al.*).

In our study, the height of the SFN division occurred proximal to the ankle, at an average of 6.87 cm, while Blair & Botte have been observed at 4.4 ± 2.9 cm. Other authors did not give measurement data, only information on whether the division of the SFN was proximal or distal to the ankle. In this regard, Takao *et al.* found such division distal to the ankle in 25% of 51 samples, and Saito & Kikuchi in 12% of 104 cases. We can therefore state that a nerve division, distal to the ankle, occurs in the minority of cases; in the majority of them, such a division occurs in the distal third of the leg, in agreement with reports by other authors (Healey & Seybold; Sunderland; Moore & Dalley).

The course of the SFN branches (MDCn and IDCn) at the level of the ankle has been observed by many authors; in our series, we measured the distance between these nerves and the anterior margin of the tibia, while others measured the distance between them and the medial and/or lateral malleolus (Blair & Botte; Saito & Kikuchi; Solomon *et al.*) or the fibularis tertius tendon (Takao *et al.*). Such a study indicates a variable course of these branches over the ankle and aims to avoid iatrogenic injury during arthroscopy of this joint, principally when it is carried out via the anterolateral approach, in which the risk of nerve damage increases (Saito & Kikuchi).

Most cutaneous innervation of the dorsum of the foot is carried out by the SFN branches, being complemented by the deep fibular (DFN) and sural (SN) nerves. It has been mentioned by other authors (Bruni; Goss; Spalteholz, 1988; Latarjet & Ruiz-Liard) that there are communicating branches between the MDCn and the DFN, as well as between the IDCn and the SN, without, however, informing with what frequency these communications appear. In our series, we observed the MDCn communicating to the DFN, at the level of the first IO space, in 53.3%, and the IDCn communicating to the SN in 33.3% of the cases. For others, such communications were more frequent: between the MDCn and the DFN in 51.7% (Kosinski) and in all cases (Canovas *et al.*); and between the IDCn and the SN, in 59.8% (Kosinski). Also, in our findings, the IDCn did not reach the dorsum of the foot in 3/30 cases and its distribution territory was substituted by the SN, a situation also observed by other researchers (Kosinski; Canovas *et al.*) in 13.7% and 10%, respectively. In the reports of Solomon *et al.*, the SN supplied the cutaneous innervation of the lateral half of the dorsum of the foot in 40%. It is therefore important that there are communicating branches between the nerves, or even the substitution of one of them by the other. This fact leads to the area anaesthetized following damage to one of the nerves (by section or crushing) being lesser.

In relation to the distribution topography of the SFN branches in the dorsum of the foot, we could observe in our samples that it was very variable, which can also be seen in researches specifically on this nerve (Kosinski; Blair & Botte; Canovas *et al.*; Takao *et al.*; Solomon *et al.*) These authors, according to their own criteria, classified this distribution into different types, which varied between three and eleven. The classification carried out by Kosinski into six types served as a standard for other researches (Canovas *et al.*; Solomon *et al.*) and in all, it was found that the most frequent type was that in which the MDCn was distributed over the medial side of the hallux, over the first metatarsal bone, first and second interosseous spaces; while the IDCn coursed over the fourth metatarsal bone and was distributed over the third and fourth interosseous spaces. This standard distribution of the SFN branches is also described in certain anatomy textbooks (Bruni; Sunderland; Goss; Latarjet & Ruiz-Liard), which, however, do not mention the possibility for variations. In our sample, on analyzing in isolation the distribution of each branch in the foot, we found this standard described above for the MDCn in 43.3% and for the IDCn in 55.5% of the cases, which was also more frequent, thereby agreeing with the authors mentioned.

All of these aspects of the SFN studied (anatomical, biometric and topographic), from its emergence at the surface to its branching in the dorsum of the foot are important, with a view to the new microsurgical techniques for the repair of nerve discontinuities, utilizing with success the SFN as a graft (Sommerschild; Buntic *et al.*). In this way, this study allows us to verify that the SFN has characteristics appropriate for this surgical technique: its emergence may be easily determined, has a considerable width (visible with the naked eye), has an epifascial course which facilitates its dissection, and due to the presence of branches communicating with other nerves, the removal of one of its branches does not result in extensive areas of cutaneous anaesthesia.

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RESUMEN: El propósito de esta investigación fue estudiar la ramificación cutánea del nervio fibular superficial (NFS), con enfoques topográfico y biométrico, para proveer mayores detalles anatómicos a las cirugías del pie y tobillo. Fueron analizados 30 miembros inferiores, derechos e izquierdos, de 15 cadáveres de individuos brasileños adultos, de sexo masculino. La ramificación cutánea del nervio fue disecada y las medidas fueron tomadas con cinta métrica y paquímetro digital. El nervio se observó en la superficie como tronco único en 66,7% de los casos y dividido en dos ramos en 33,3%. Cuando se presentó como tronco único, emergió a nivel del tercio distal de la pierna en 75%, en el límite entre los tercios medio y distal en 20%, y, en el tercio medio en 5%. Cuando se presentó dividido, los dos ramos tuvieron la misma topografía en 60% de los casos, en general, el tercio distal de la pierna. Al salir a la superficie, el promedio del diámetro externo del nervio, cuando era único, fue de 3,1 ± 0,8 mm, y cuando estaba dividido, uno de sus ramos, el nervio cutáneo dorsal medial (nCDM) del pie, midió 2,4 ± 0,9 mm, y el otro, el nervio cutáneo dorsal intermedio (nCDI) del pie, 2,1 ± 0,6 mm. El nCDM se comunicó con el nervio fibular profundo en 53,3% y el nCDI con el nervio sural en 33,3%. En su distribución en el dorso del pie, el nCDM estuvo relacionado principalmente con el 1er hueso metatarsiano y los dos primeros espacios interóseos, mientras que el nCDI, se relacionó en general, con el cuarto hueso metatarsiano y el tercero y cuarto espacios interóseos. La emergencia y ramificación cutánea del NFS presentan importantes variaciones que deben ser conocidas para evitar lesiones iatrogénicas durante procedimientos quirúrgicos el en pie y tobillo.

PALABRAS CLAVE: Anatomía; Pierna; Pie; Nervios; Nervio fibular superficial.

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Recibido : 11-03-2005
Aceptado: 28-05-2005