

Clinical anatomy of the superficial peroneal nerve in the distal leg

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SUMMARY

Applied anatomy of the superficial peroneal nerve in real clinical situations requires a good knowledge of the anatomical relationships and their common variations. Here we present an anatomoclinical description not only of the normal superficial peroneal nerve but also of its different variations with surgical implications based on twelve lower limbs.

In order to gain some landmarks, the followings measurements were taken: a) distance from the upper end of the fibular head to the lower eminence of the lateral malleolus; b) number of branches from the nerve when it emerges through the superficial sural fascia; c) distance from the nerve emergence point to the lateral malleolus; d) distance from the nerve division to the lateral malleolus. We also recorded the site where the nerve pierces the sural fascia from the anterior or lateral muscular compartment.

The data obtained seem to be sufficiently reliable for usual clinical practice, but it must be taken into account that frequent and important variations may occur.

Key words: Superficial peroneal nerve – Anatomical variations – Surgical anatomy

INTRODUCTION

The classical description of the superficial peroneal nerve (SPN) is a starting point for medico-

surgical clinical applications. Nevertheless, although simple in principle descriptive anatomy may encounter significant difficulties when used in real clinical situations due to the anatomical relationships themselves or to common variations in them.

Applied clinical anatomy requires a good knowledge of the operative area with pinpoint accuracy. A small injury to the anterolateral and distal area of the leg can cause a SPN section that may initially pass unnoticed unless a specific and targeted examination is performed. Thus, a deep knowledge of nerve anatomy and its potential variations is needed. Furthermore, when such information is missing iatrogenic injuries may occur in a whole range of clinical manoeuvres (poorly applied bandages causing neural compression; fasciotomies; arthroscopic ports, and common surgical approaches for osteosynthesis in the distal third of the fibula).

The superficial peroneal nerve is classically described as one of the terminal branches of the peroneal or lateral popliteal nerve containing nerve projections from L4 and L5 roots. In the popliteal area, the peroneal nerve follows the upper and lateral border along the biceps femoris muscle until it reaches the posterior area of the fibular head, where it changes course. The nerve courses around the fibular neck and under the long peroneal muscle, where it divides into its terminal branches, including the SPN or musculocutaneous nerve of the leg. The superficial peroneal nerve passes down along the leg, under the long peroneal muscle, with motor

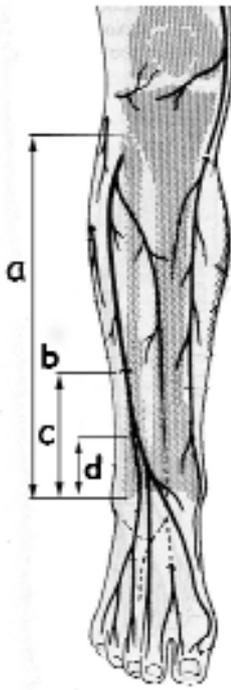


Figure 1. Measures taken in our research. **a:** distance (in mm) from the upper end of the fibular head to the lower eminence of the lateral malleolus; **b:** number of branches from SPN when it emerges through the superficial sural fascia; **c:** distance (in mm) from the SPN emergence point to the lateral malleolus; **d:** distance (in mm) from the SPN division to the lateral malleolus.

branches from the nerve innervating the long peroneal muscle and short lateral peroneal muscle. The main nerve trunk courses to the intermuscular septum between the lateral and anterior compartments. In the lower third of the leg, the nerve pierces the superficial fascia and enters subcutaneous cellular tissue. The musculocutaneous nerve of the leg further descends to the foot, where it divides into two branches to innervate the skin in the dorsal surface of the foot. These terminal branches (medial and middle dorsal cutaneous nerves) are sensitive nerves for the most of the dorsal surface of the foot and toes, except the medial border (saphenous nerve), first web area (deep peroneal nerve), and lateral border (lateral dorsal cutaneous nerve, a branch of the sural nerve). Most of the classical anatomy textbooks include such a description of the course and distribution of the SPN, although some very important variations may occur in clinical practice. Sometimes, the SPN pierces the intermuscular septum and passes from the lateral compartment into the anterior compartment, following a superficial course. In other cases, the medial and middle dorsal cutaneous nerves divide before the superficial fascia is pierced.

The aim of the present work was to offer an anatomico-clinical description that could be of practical value and a description of the most common

variations, in order to alert physicians to the possibility of iatrogenic injuries and help to achieve a more accurate diagnosis of traumatic and compressive insults involving these structures.

MATERIALS AND METHODS

A dissection was performed in twelve lower limbs (six from men and six from women) that had been preserved in a formol solution. There were seven (58.33%) right legs and five left legs (41.66%), the difference being due to the fact that only in some cases were both lower limbs available. The subcutaneous layer was carefully dissected in each preparation so that distortion of neural structures and their relationships would be avoided as far as possible. Once the nerve structures had been identified, the following measurements were performed: a) distance (in millimeters) from the upper end of the fibular head to the lower eminence of the lateral malleolus; b) number of branches from SPN when it emerges through the superficial sural fascia; c) distance (in millimeters) from the SPN emergence point to the lateral malleolus; d) distance (in millimeters) from the SPN division to the lateral malleolus. We also had recorded the place where the SPN pierces the sural fascia from the anterior or lateral muscular compartment (Fig. 1).

After completing these measurements, a deep and wide dissection was performed, especially in those cases showing some variations, so that the anatomy of the SPN could be observed and duly classified along its entire course. A computer was used to organize and process all the data acquired.

RESULTS

There were two main findings from these dissections. First, we observed variations in the number of branches passing through superficial anterior fascia of the leg. Some cases showed a single trunk emergence, later dividing into two branches, while others showed two different previously divided cutaneous branches (Table 1). Second, in both anatomical types, a marked variation was observed in the relative distance from the lateral malleolus, emerging at a low, medium or high level (Figs. 2a, 2b).

Regarding the compartment from which the SPN pierces the superficial fascia, the difference between single-trunk and two branches should be taken into account. The results for single trunks are shown in Table 2. Three specimens displayed a SPN bifurcation before nerve emergence; two of them had a superficial branch piercing the superficial fascia from the anterior

Table 1.- Frequency of a single-trunk for superficial peroneal nerve and two independent nerve branches when emerging.

	Number of cases	Percentage
Single-trunk	9	75%
Two branches	3	25%

Table 2.- Cases with a single trunk for the SPN when emerging.

	Number of cases	Percentage
Emergence from anterior compartment	3	33.33%
Emergence from lateral compartment	5	55.55%
Emergence on intermuscular septum	1	11.11%

compartment and a second branch emerging from the lateral compartment. In the other specimen, both branches emerged from the anterior compartment (Figs. 3a, 3b).

The level at which the SPN pierces the superficial fascia in the leg and penetrates into the subcutaneous cellular tissue is important. On average, the SPN becomes superficial at 116.8 mm proximal to the lateral malleolus; i.e., in 95% of cases SPN emergence is between 166 and 66 mm above the lateral malleolus, assuming a normal distribution for this distance (95% confidence interval = mean \pm 2 standard deviation).

These data in millimeters could be misleading in people with extreme morphometric parameters, and defining the emergence point for the SPN as a percentage of leg length is much more useful. The level at which the SPN becomes superficial was expressed as a percentage of the distance from the fibular head to the lateral

malleolus, two palpable bone eminences aiding clinical application. According to such measurements, SPN emergence represents 33.53% of the lateral malleolus-fibular head distance; in other words, at the upper two-thirds/lower-third limit level of fibular length (Table 3).

The SPN division level may also be important in some clinical cases. Clearly, in cases with the SPN piercing the fascia after having divided into two branches, the division point is proximal to the emergence point. In such cases, we observed that nerve division is on average 226 mm above the lateral malleolus. This distance represents some 64.29% of the distance from the lateral malleolus to the fibular head; i.e., at the upper-third/lower two-thirds limit level in the leg. On the other hand, in (more common) cases with the SPN piercing the superficial fascia as a single trunk, nerve division is 66 mm proximal to the lateral malleolus; i.e., some 18.87% of the distance from the lateral malleolus to the fibular head, representing the upper 4/5 / lower 1/5 limit level in the leg (Table 4).

DISCUSSION

Clinical interest in an accurate knowledge of SPN courses and relationships involves several specialties. In patients with direct traumas or injuries to the anterolateral aspect of the distal third of the leg, potential involvement of this structure must be explored by means of sensitive examination in its autonomous innervation area. Neurophysiologists, however, could be interested in establishing the exact point at which to place electrodes to obtain an electroneurographic record, and finding its superficial localization could be necessary. There is a physical sign to identify the SPN just below the skin, by means of a plantar flexion and inversion of the ankle and

Table 3.- Peroneal length and emergence point of the SPN.

	Mean	Standard dev.	Maximum	Minimum
Lateral malleolus-fibular head distance	351.5 mm	29.33 mm	400 mm	313 mm
Malleolus-emergence distance	116.87 mm	25.21 mm	135 mm	35 mm
Malleolus-emergence distance in percentage of fibular length	33.53 %	7.83 %	42.72 %	11 %

Table 4.- Distance between the malleolus and the division of the SPN.

	Mean	Standard dev.	Maximum	Minimum	Percentage
Division-malleolus distance (all cases)	95.36 mm	69.36 mm	265 mm	36 mm	27.13%
Single-trunk	66.33 mm	20.48 mm			18.87%
Two branches	226 mm	55.15 mm			64.29%



Figure 2. a, b: Cases of a SPN with two separated branches before becoming subcutaneous. Notice that in 2b, the middle dorsal cutaneous nerve emergence point is very distal.

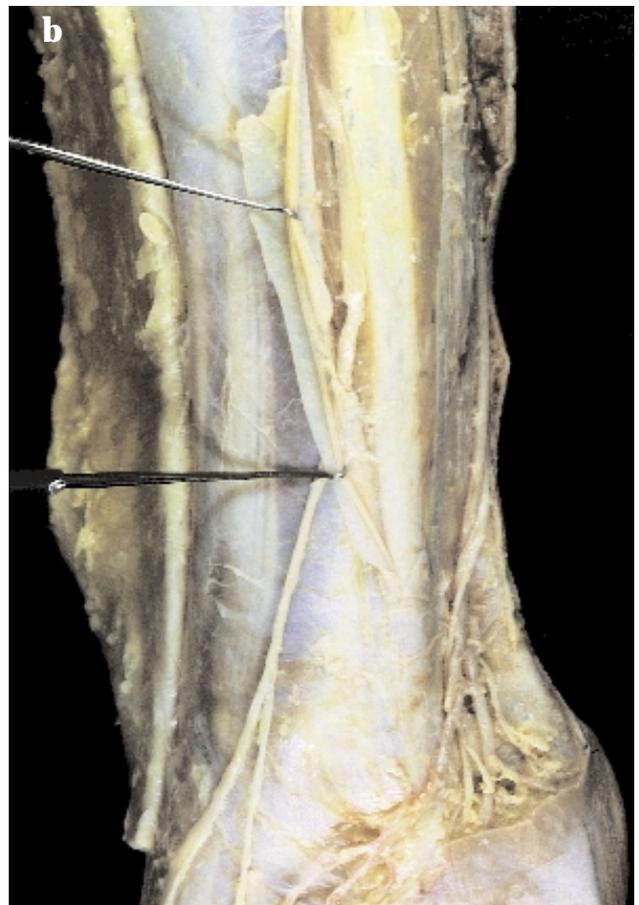


Figure 3. SPN piercing sural fascia from anterior (a) or lateral (b) muscular compartment.

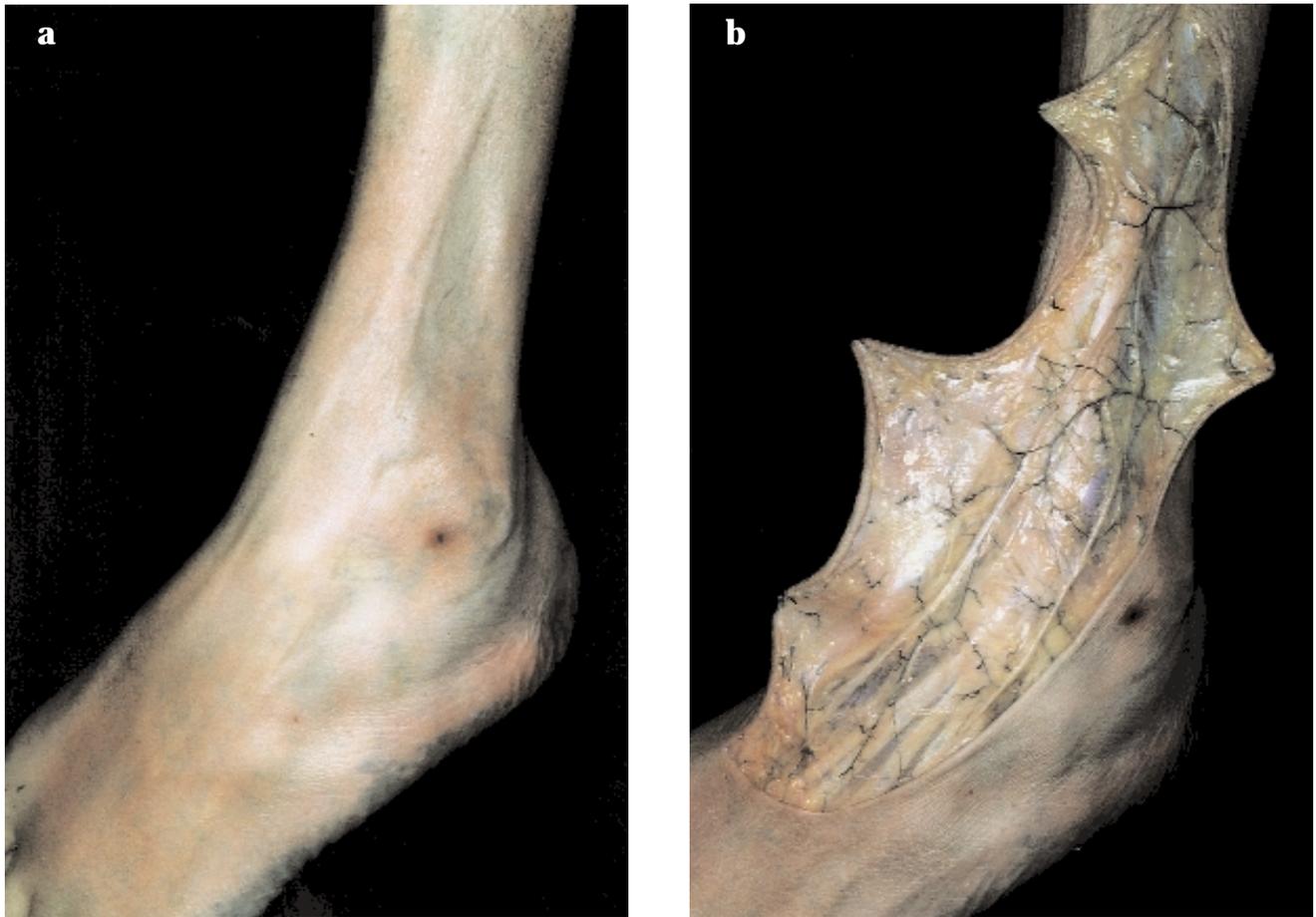


Figure 4. a, b: Fourth toe flexion sign. In some cases it is possible to visualize the SPN subcutaneously.



Figure 5. Appearance of the SPN in a case of acute compartment syndrome.

foot and, secondarily, a passive flexion of the fourth toe (Figs. 4a, 4b). In this way, the distal subcutaneous course of the SPN can be identified (Stephens, 2000). In the field of orthopaedic surgery, some experts in peripheral nerve surgery have suggested using this nerve as a vascularized graft, because it is usually accompanied by a small artery and vein, or using the motor branches to the peroneal muscles for a neurotization of the anterior tibial muscle in patients with L4 root injuries (polio, spinal injuries, and others). Neither therapeutic option is currently being used in clinical practice, but studies have been planned to assess their potential use in the near future (Buyukmumcu, 1999). On the other hand, in plastic surgery small arteries and veins accompanying the SPN are being used in vascularized skin grafts (Masquelet, 1992).

In some quite common situations, such as arthroscopy, there is a close relationship between ankle ports and the risk of injury to the SPN terminal branches (Blair, 1994; Canovas, 1996; Takao, 1998).

Also, when an anterolateral fasciotomy is performed due to a compartment syndrome of the leg, SPN position implies a risk for the nerve, injuries and sensitive sequelae not being uncommon (Adkinson, 1991) (Fig. 5).

One of the surgical manoeuvres that may involve the highest risk of SPN iatrogenic injuries is the lateral approach usually used in fibular osteosynthesis to treat ankle fractures. The surgical dogma requiring a direct incision from the skin to the fibula, avoiding a layer dissection, may cause inadvertent sectioning of the nerve if the exact position has not been identified or an anatomical variant exists (Huene, 1995). Percutaneous emplacement of pins or screws, such as those used for external fixing devices, or bolts to block tibial endomedullary nails can also cause nerve injuries.

SPN compressive syndromes have also been described where the nerve pierces the superficial fascia of the leg, causing a clinical picture similar to an L5 root disease (dysesthesia on the dorsal surface of the foot and respective toes). This situation requires an accurate differential diagnosis (Styf, 1989).

In all the above situations, precise identification of the course of the SPN is extremely important. Our data are readily applicable and are sufficiently reliable for usual clinical practice. It should be recalled, however, that certain important variations may occur. In some 75% of cases, the SPN appears as a single nerve trunk, but in

the remaining 25% of patients it appears as two separate branches. This must be taken into account so that the second SPN branch is not injured after locating a branch when performing a surgical procedure.

According to classical descriptions, the SPN pierces the superficial fascia of the leg from the lateral compartment (55%), although in a not inconsiderable percentage of cases (35%) it comes from the anterior compartment. Furthermore, SPN emergence can be found at the upper two-thirds/lower third limit level of the fibular length. Although all these data will help to locate the SPN with a high degree of reliability, it will never be possible to reach the 100% level. This is why a deep knowledge of nerve SPN anatomy and good surgical skills to find the nerve and avoid causing nerve injuries are required.

REFERENCES

- ADKINSON DP, BOSSE MJ, GACCIONE DR and GABRIEL KR (1991). Anatomical variations in the course of the superficial peroneal nerve. *J Bone Joint Surg*, 73: 112-114.
- BLAIR JM and BOTTE MJ (1994). Surgical anatomy of the superficial peroneal nerve in the ankle and foot. *Clin Orthop*, 305: 229-238.
- BUYUKMUMCU M, USTUN ME, SEKER M, KOCAOGULLARI Y and SAGMANLIGIL A (1999). The possibility of deep peroneal nerve neurotisation by the superficial peroneal nerve: an anatomical approach. *J Anat*, 194: 309-312.
- CANOVAS F, BONNEL F and KOULOUMDJIAN P (1996). The superficial peroneal nerve at the foot. Organization, surgical applications. *Surg Radiol Anat*, 18: 241-244.
- HUENE D, BUNNEL W and LINDA L (1995). Operative anatomy of nerves encountered in the lateral approach to the distal part of the fibula. *J Bone Joint Surg*, 77: 1021-1024.
- KOSINSKI C (1926). The course mutual relations and distribution of the cutaneous nerves of the metatarsal region of leg and foot. *J Anat Physiol*, 60: 274-297.
- MASQUELET AC, ROMANA MC and WOLF G (1992). Skin island flaps supplied by the vascular axis of the sensitive superficial nerves: anatomic study and clinical experience in the leg. *Plastic & Reconstructive Surg*, 89: 1115-1121.
- ORTS LLORCA F (1980). Sistema nervioso periférico. In: *Anatomía Humana*. Editorial Científico-Médica, Barcelona, pp 369-370.
- STEPHENS MM and KELLY PM (2000). Fourth toe flexion sign: a new sign for identification of the superficial peroneal nerve. *Foot & Ankle Int*, 21: 860-863.
- STYF J (1989). Entrapment of the superficial peroneal nerve: diagnosis and results of decompression. *J Bone Joint Surg*, 71: 131.
- TAKAO M, UCHIO Y and OCHI M (1998). Anatomic bases of ankle arthroscopy: study of superficial and deep peroneal nerves around anterolateral and antero-central approach. *Surg Radiol Anat*, 20: 317-320.
- TESTUT L and LATAJET A (1942). Sistema nervioso periférico. In: *Tratado de Anatomía Humana*. Salvat Editores S.A, Barcelona, pp 352-353.