Acta Medica Alanya

CASE REPORT

OLGU SUNUMU

Acta Medica Alanya

2024;8(2): 160-164

DOI: 10.30565/medalanya.1486986

A Variation of the Double Deep Fibular Nerve with Multiple Connections to the Superficial Fibular Nerve on the Dorsal Aspect of the Foot

Ayağın Dorsal Yüzünde Nervus Fibularis Superficialis ile Çoklu Bağlantılara Sahip Çift Nervus Fibularis Profundus Varyasyonu

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ABSTRACT

In this report, we aim to present our observation of a rare variation on the dorsum of the foot, including the double deep fibular (peroneal) nerve and its connections to superficial nerves. The cutaneous nerves of both feet ' dorsum were examined during a routine dissection on a formalin-fixed adult male cadaver. During the dissection of the dorsum of the right foot, it was observed that the deep fibular nerve (DFN) surfaced at two distinct points by piercing the investing fascia. Then, these two branches converged, and DFN had connections at three different points with the superficial fibular (peroneal) nerve (SFN). However, the superficial nerve anatomy of the dorsum of the left foot exhibited the anatomical structure commonly described in classical textbooks. To the best of our knowledge, the variation of double DFN with multiple connections to the SFN has not been previously described in the literature. Understanding the innervation of the dorsum of the foot may be clinically substantial in preventing nerve injuries during surgical interventions. The knowledge regarding rare superficial nerve variations may contribute to the success of anaesthesia applications, especially in the ankle and dorsum of the foot.

Keywords: Fibular nerve, peroneal nerve, cadaver, variation, cutaneous innervation

ÖZ

Bu vaka raporunda ayak sırtında çift nervus fibularis (peronealis) profundus (DFN) ve yüzeyel sinirlerle olan bağlantılarını içeren nadir bir varyasyona ilişkin gözlemimizi sunmayı amaçladık. Formalinle fikse edilmiş yetişkin bir erkek kadavra üzerinde rutin eğitim diseksiyonu sırasında her iki ayak sırtının kutanöz sinirleri incelendi. Sağ ayak sırtı diseksiyonu sırasında DFN'nin fascia investiens'i iki ayrı noktada delerek yüzeye çıktığı görüldü. Daha sonra bu iki dal birleşti ve DFN'nin nervus fibularis (peronealis) superficialis (SFN) ile üç farklı noktada bağlantısı oldu. Ancak sol ayak sırtının yüzeyel sinir anatomisi, klasik ders kitaplarında yaygın olarak tanımlanan anatomik yapıyı sergiliyordu. Bildiğimiz kadarıyla, çift DFN'nin SFN'ye çoklu bağlantılarla varyasyonu literatürde daha önce tanımlanmamıştır. Ayak sırtının innervasyonunun anlaşılması, cerrahi müdahaleler sırasında sinir yaralanmalarının önlenmesi açısından klinik açıdan önemli olabilir. Nadir görülen yüzeysel sinir varyasyonlarının bilinmesi, özellikle ayak bileği ve ayak sırtında anestezi uygulamalarının başarısına katkı sağlayabilir.

Anahtar Kelimeler: Nervus fibularis, nervus peroneus, kadavra, varyasyon, kutanöz inervasyon

RECEIVED: 20.05.2024 ACCEPTED: 15.08.2024 PUBLISHED (ONLINE): 30.08.2024

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To cited: Kucuker M, Kacar H. Ozen KE. A Variation of the Double Deep Fibular Nerve with Multiple Connections to the Superficial Fibular Nerve on the Dorsal Aspect of the Foot Acta Med. Alanya 2024;8(2): 160-164 doi: 10.30565/medalanya.1486986

Introduction

The cutaneous innervation of the dorsum of the foot is supplied by the superficial fibular nerve (SFN), deep fibular nerve (DFN), and sural nerve (SN). During its course, SFN gives motor branches to the lateral compartment muscles. It becomes superficial at 1/3 of the distal part of the leg. It moves to the dorsum of the foot and is divided into two branches known as the medial branch of the medial dorsal cutaneous nerve of the foot (MDCNF) and the intermediate dorsal cutaneous nerve of the foot (IDCNF). The medial branch of MDCNF innervates the medial aspect of the great toe, while the lateral branch innervates the adjacent surfaces of the second and third toes. IDCNF provides sensory innervation to a substantial portion of the dorsum of the foot, the lateral aspect of the third toe, both sides of the fourth toe, and the medial surface of the fifth toe [1].

The anterior tibial artery accompanies DFN on the anterior surface of the interosseous membrane of the leg. After crossing, the inferior extensor retinaculum divides into medial and lateral terminal branches. The medial terminal branch of the DFN runs with the dorsalis pedis artery on the dorsum of the foot, is divided into two branches at the first intermetatarsal space, and becomes superficial. These branches innervate the adjacent sides of the first and second toes. The lateral terminal branch of the DFN travels deep into the ankle and penetrates the extensor digitorum brevis muscle, expanding like a pseudo-ganglion before innervating the muscle. Additionally, the SN passes behind the lateral malleolus and continues as the lateral dorsal cutaneous nerve of the foot (LDCNF), supplies the skin on the lateral side of the little toe [1].The branching pattern of the SFN should be considered in procedures such as flap surgery in the dorsum of the foot [2], it is essential to note that iatrogenic injuries of cutaneous nerves are common complications in surgical interventions of the foot and ankle region [3].

This case report describes a variation of the DFN/SFN. We aimed to present our observation regarding the communicating branches between DFN and branches of SFN, as well as the atypical course and branching pattern of DFN.,

Case Presentation

The study followed the ethical principles outlined in the 1964 Declaration of Helsinki and its later amendments. The dissection was performed on a cadaver obtained in compliance with national legal and ethical procedures and kept in the Anatomy Laboratory of the Medical Faculty. Informed consent was obtained during cadaver donation process. During a routine educational dissection performed on a formalin-fixed adult male cadaver in our laboratory, the cutaneous nerves of the right and left dorsal aspects of both feet were examined. The cadaver had no lower extremity deformity. On the right side, SFN was superficial at the 1/3 distal part of the leg proximal to the ankle. Just before crossing the ankle, SFN divided into two branches. These branches are described as the intermediate dorsal cutaneous nerve of the foot (IDCNF) and the medial dorsal cutaneous nerve of the foot (MDCNF). These branches were coursing towards the dorsum of the foot (Figure 1).

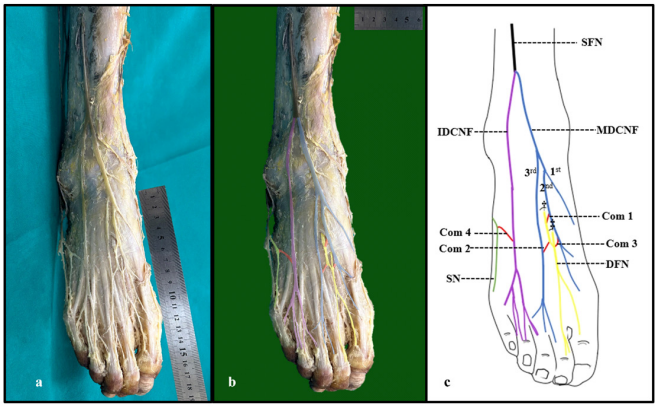

Figure 1. Cutaneous innervation on the dorsum of the right foot. a. Original photograph. b: coloured/illustrated photograph. c: schematic view. [Yellow, deep fibular nerve (DFN); Black, superficial fibular nerve (SFN; Blue, medial dorsal cutaneous nerve of the foot (MDCNF) (1st: first branch, 2nd: second branch, 3rd: third branch); Purple, intermediate dorsal cutaneous nerve of the foot (IDCNF); Red: communicating branches (Com1, Com2, Com3, Com4), Green, sural nerve (SN); †: deep fibular nerve 1 (DFN1), ‡: deep fibular nerve 2 (DFN2).]

At the first intermetatarsal space on the right foot, in the proximal-distal direction, two nerves were observed where DFN was expected to become superficial by piercing the fascia investiens. The distal nerve originated from the proximal nerve just beneath the investing fascia. These nerves were named DFN1 (located proximally) and DFN2

(located distally). DFN2 was running medially to DFN1. Then, DFN1 and DFN2 converged to a single DFN.MDCNF was divided into three distinct branches on the dorsum of the foot. The first branch extended to the medial aspect of the great toe. With an intermediate course, the second branch gave branches extending the dorsal aspect of the same toe. The third branch extended to the second toe's lateral aspect and the third toe's medial aspect.

MDCNF was communicating with the branches of the DFN at three points. These branches were named Com 1, Com 2, and Com 3. Com 1 established a connection between the DFN1 and the second branch of MDCNF, while Com 2 established a connection between the DFN1 and the third branch of MDCNF. Com 3 connected the nerve formed by the convergence of DFN1 and DFN2 and the second branch of MDCNF. IDCNF was divided into branches extending to the lateral aspect of the third toe, both sides of the fourth toe, and the medial aspect of the fifth toe. A communicating branch (Com 4) arose from the SN and joined this nerve on the dorsum of the left foot, the DFN was branching at the first intermetatarsal space and supplied the adjacent surfaces of the first and the second toe. The SFN and the SN innervated the rest of the dorsum of the foot. We observed that the cutaneous nerves on the dorsum of the left foot were consistent with the basic descriptions in classical anatomical textbooks [1].

Discussion

In our report, we observed that (I) DFN became superficial at two different distinct points by piercing the investing fascia at the first intermetatarsal space, resulting in the formation of two branches (DFN1 and DFN2), (II) then these two branches converged, and (III) DFN1 and DFN2 contact with MDCNF at three points with communicating branches on the dorsum of right foot. We observed that DFN1 and DFN2 provided superficial innervation to the adjacent sides of the first and second toes. On the dorsum of the left foot, a familiar anatomical pattern, frequently encountered in essential resources, was observed regarding the superficial nerves [1].

There are many studies in the literature regarding the innervation of the dorsum of foot [4-9]. The earliest document we could find and access was published in 1891 by the Collective Research Committee of the Great Britain and Ireland Anatomy Society. According to this report, 229 dorsa of feet were examined, and variations were classified into 12 types (Type A-L). The most common variation according to this classification is Type A (%55, classical type) [8]. Type A appears consistent with the most commonly observed anatomical pattern and is accepted as usual in classical textbooks. However, the terminology used by Thomson is no longer in use today [10]. In this source, the terms musculocutaneous nerve for SFN, internal branch for MDCNF, external branch for IDCNF, anterior tibial nerve for DFN, and external saphenous nerve for SN were preferred [8]. The classification of Thomson et al. was compiled by current terminology, and 12 types (Type K1-12) were defined as Kosinski's classification [6]. However, the variation observed on the right foot in our case was not included in these classifications.

Cheredath et al. reported 5 variations in their study about cutaneous nerve innervation of the dorsum of the foot in the Indian population. The vast majority of variations they identified were observed in the sural nerve. Among these types, there was a communicating branch between SFN and DFN, and DFN became superficial from a single point in variations 2 and 3 [4]. In another study conducted by Nayak et al., cutaneous nerve innervation of the dorsum of the foot was classified into four groups in the Indian cadavers. They identified the communicating branch between MDCNF and DFN in 10% of the cases. This variation was defined as Group 4 [7]. In our case, DFN formed communicating branches with MDCNF at three different points in the variational pattern observed on the dorsum of the right foot. Additionally, the presence of the superficialising of the DFN from two distinct points in the first metatarsal interspace was not concordant with any specific variation type.

In a fetal cadaver study in India, the innervation of the dorsum of the foot was classified into 4 main types. Main variation types were divided into subtypes by considering the locations of the communicating branches between the nerves that supply the dorsum Type 1a-g, Type 2a-d, Type

3, Type 4a-c) [5]. According to this classification, in 25% of the cases, at least one communicating branch was observed between the SFN and DFN. Type 1f was the most concordant variation with our case. In this type, there are three communicative connections ‘‘C1: communication between DFN and MDCNF, between MDCNF and IDCNF, and between IDCNF and SN). In our case, although DFN innervated the same region that is described in Type 1f, DFN reported in our report superficialised at two distinct points (DFN1 and DFN2), and DFN1 and DFN2 were communicating with MDCNF at three different points.

In the literature, to the best of our knowledge, the only study in which double DFN is defined in the dorsum of the foot is a fetus study in the Indian population. In this study, the cutaneous nerves of the dorsum of the foot were classified into six main types. DFN was defined as Type 4b by superficialising at two distinct points. Type 4b (1.7%) was scarce, and the innervation region of the DFN was the adjacent sides of the second and third toe in addition to the adjacent sides of the first and second toe [9]. In our report, DFN1 and DFN2, which became superficial from 2 different points, merged again and innervated only the first interphalangeal space (adjacent sides of the first and second toe). DFN1 and DFN2 also established multiple communicating branches with SFN (Com1: between DFN1 and NCMDP 1st branch, Com2: between DFN1 and MDCNF 2nd branch, Com3: between the union of DFN1 and DFN2 and MDCNF 2nd branch, Com4: between SN and IDCNF).

Clinical Importance

According to a systematic review examining complications of ankle arthroscopy procedures, neurological injuries are the most common among all complications, with 55.4% (180/325). SFN is affected in 32.7% of all neurological injuries. In addition, it has been reported that 20% of all neurological damage is permanent [3]. Injuries in the distal part of the DFN primarily lead to sensory deficits and the formation of painful neuromas [11].

In addition, different variations of these cutaneous nerves should be considered in nerve block anaesthesia of the foot and ankle region and during the evaluation of chronic traumatic or atraumatic pain syndromes of the leg [12].

Conclusions

In this case we presented a rare cutaneous variation of DFN on the dorsum of the foot. The knowledge of such as these variations can provide a deeper understanding of the clinical reflections of the neural network of the foot. Thus, we believe that it will be beneficial for surgeons and clinicians dealing with the region in terms of less iatrogenic injuries and better postoperative results.

Conflict of Interest: The authors declare no conflict of interest related to this article.

Funding sources: The authors declare that this study has received no financial support.

Ethics Approval and/or Informed consent: The study followed the ethical principles outlined in the 1964 Declaration of Helsinki and its later amendments. The dissection was performed on a cadaver obtained in compliance with national legal and ethical procedures and kept in the Anatomy Laboratory of the Medical Faculty. Informed consent was obtained during cadaver donation process.

ORCID and Author contribution: All authors contributed to the study's conception and design. **M.K. (0000-0002-9267-1164):** Material preparation and dissection, writing. **H.K. (0000-0003-4804-3678):** Material preparation and dissection. **K.E.O. (0000-0002-9778-3325):** reviewed and edited the manuscript. All authors read and approved the final manuscript.

Acknowledgements: The authors deeply appreciate those generously donating their bodies to science, enabling vital anatomical research. The findings from such studies have the potential to significantly enhance our collective understanding, ultimately leading to improved patient care. For this reason, we extend our utmost gratitude to these donors and their families.

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