Journal of the Anatomical Society of India 67 (2018) 130–132

Contents lists available at ScienceDirect

Journal of the Anatomical Society of India

journal homepage: www.elsevier.com/locate/jasi

Original Article

The effects of the communicating branch between medial and lateral plantar nerves on the innervations of the foot lumbrical muscles

Cüneyt Bozer[a], Deniz Uzmansel[b], Didem Dönmez[a], Muhammed Parlak[a], Orhan Beger[b,*], Özlem Elvan[b]

[a] Trakya University, Faculty of Medicine, Department of Anatomy, Edirne, Turkey
[b] Mersin University, Faculty of Medicine, Department of Anatomy, Mersin, Turkey

ARTICLE INFO

Article history:
Received 1 November 2017
Accepted 6 November 2018
Available online 13 November 2018

Keywords:
Lateral plantar nerve
Medial plantar nerve
Lumbrical muscles
Deep branch of lateral plantar nerve
Communicating branch
Foot

ABSTRACT

Introduction: The communicating branches between the medial (MPN) and lateral (LPN) plantar nerves aren't frequently observed in relation to the innervation of the foot muscles in previous studies. In this study, the number and localization of the communicating branch on the innervations of foot muscles were evaluated to open a new sight considering the innervations of lumbrical muscles.
Material and methods: 30 formalin-fixed feet (15 right – 15 left feet), with an average age of 76 from the inventory of Trakya and Mersin University Anatomy Departments in 2015 were dissected. The innervations of the lumbricals and the communicating branches were revealed and then photographed.
Results: In all feet, first lumbricals were observed to be innervated by MPN, while the remaining muscles were innervated by deep branches of LPN. In four cadaveric feet, communicating branches of MPN, LPN and deep branch of LPN were appeared but, in one of them, proximal to the branches of MPN and LPN to lumbricals, a communicating branch between MPN and deep branch of LPN were observed.
Discussion: Data about the innervations of the lumbricals were found to be consistent with the previous studies. Taking into account the localization of the communicating branches between the MPN and LPN, it should be considered that nerve injuries during surgical procedures such as flexor tendon transfers, island flap surgery, treatment of hallux valgus or lesser toes deformity in the foot and ankle region may unexpectedly lead to different functional failures.

1. Introduction

Lumbrical muscles in the hands and feet were taken from the lumbricus, which is reffered to the meaning of *worm* in Latin, due to the similarity in shape.[1] The four lumbricals in foot, named by numbering from the medial to the lateral, begin at tendons of flexor digitorum longus and end to the dorsal digital expansions of proximal phalanges of lesser toes.[2] They provide extension of the proximal and distal interphalangeal joint and flexion of the metatarsophalangeal joint.[2,3] However, due to the decrease in muscle size and the increase in muscle spindles, it has been reported that lumbricals perform a sensory function more than a motor.[3] As a result, the lumbricals, the sensory and motor connection between the flexor and extensor tendons are known to be contributing to the movement of the feet during walking and stance.[2],[3]

According to the standard text books of anatomy and previous research reports, the first lumbrical is innervated by the medial plantar nerve (MPN) and the remainder three lumbricals are innervated by the deep branch of the lateral plantar nerve (LPN) [2,4–6] The variations of this innervations were reported rarely in the literature.[4,6] Although there are many studies evaluating the branching patterns of MPN and LPN and communicating branches between plantar nerves,[5–8] a direct relationship between lumbricals innervation and communicating branches were reported only in the study of Akita et al.[6]

In the current study, considering the communicating branches between MPN and LPN, it is planned to determine the innervations of the foot lumbricals and to interpret our data with a new sight.

2. Materials and methods

In order to increase the number of dissected specimens, the study was performed in two different anatomy departments in Turkey from June to September 2015. With the collaboration of Anatomy Departments of Trakya and Mersin Universities, 11 and 19 cadaveric feet were dissected under dissection microscope,

* Corresponding author at: Mersin University Faculty of Medicine, Department of Anatomy, Ciftlikkoy Campus, 33343, Mersin, Turkey.
E-mail address: obeger@gmail.com (O. Beger).

https://doi.org/10.1016/j.jasi.2018.11.006

respectively. Observations were made on 19 feet of 10 adult cadavers (8 males and 2 females, 9 right and 10 left feet) and 11 feet of 7 adult cadavers (6 males and 1 female, 6 right and 5 left feet) which were fixed by 10% formalin solution. Due to the deformation, 4 feet were excluded the study.

In the dissection procedure, after careful removal of the superficial part of the foot, including skin, subcutaneous fascia, plantar aponeurosis, flexor digitorum brevis muscle was cut from its origin. Then, abductor hallucis muscle was cut from its insertion. Starting from the muscular retinaculum, the detailed course of MPN and LPN were investigated. For the observation of the dorsal surface of the muscles, quadratus plantae muscle was cut. The innervations of the lumbrical muscles and communicating branches between MPN and LPN were noted and then photographed.

3. Results

In all thirty cadaveric feet, we could not find any variation different from the innervations of the lumbricals of the foot, written in standard anatomical books. MPN innervated the first lumbrical (Fig. 1a) and deep branch of LPN innervated the remaining lumbricals (Fig. 1b). Communicating branches between nerves were observed in 4 cases:

- 1 case between MPN and MPN (between superficial branch of MPN and the first common digital plantar nerve of MPN) (Fig. 2a),
- 2 cases between the MPN and LPN (between the third common digital plantar nerve of MPN and the common digital plantar nerve of LPN) (Fig. 2b), and
- 1 case between MPN and the deep branch of LPN (between first common digital plantar nerve of MPN and deep branch of LPN) (Fig. 2c).

4. Discussion

The lumbricals function is described as extension of the proximal and distal interphalangeal joint and flexion of the metatarsophalangeal joint.[3] Compressing both metatarsophalangeal and interphalangeal joints provide a unique ability to the lumbricals.[9] In this way, the lumbricals, along with the other intrinsic muscles, may assist the control movements of the forefoot during stance and rear foot during gait.[3,9] In addition to motor function, lumbricals should be considered as acting a proprioceptive role due to the muscle spindles they possess.[2,3] Thus, with this sensory and motor function, lumbricals provide an important role in coordination of the movements of the foot during stance and gait.[3] Lumbrical dysfunction, which occurs in tibial nerve injuries and hereditary motor-sensory neuropathies such as Charcot-Marie-tooth disease, contributes to clawing of the toes.[2,9,10]

Although variations in innervation in the hand lumbricals are commonly seen, the innervation of the foot lumbricals is fairly constant.[4] There are only two studies in the literature concerning the variation of the innervations of the foot lumbricals.[4,6] Brooks[4] reported a variation in innervation of the foot lumbricals only one case in 10. In that case, the first and second lumbricals were innervated by both MPN and the deep branch of LPN and also the third and fourth lumbricals were innervated by the deep branch of LPN.[4] In the same study, it was observed that for the lumbricals in hand, there were 12 different innervations in 21 cases.[4] In only one of the 38 foot, Akita et al.[6] reported a communicating branch between the deep branch of LPN and the branch of MPN that innervate the first lumbrical. We could not find any variation from the innervations of the lumbricals of the foot, written in anatomical text books.[2,11] However, communicating branches between MPN, LPN and deep branch of LPN were detected in 4 cases.

Data related to the incidence of communicating branches between MPN and LPN is quite variable in the literature.[7,8,12] Although Jones and Klenerman[7] reported that there were communicating branches between MPN and LPN in all 20 feet, Levitsky et al.[12] reported 19 of 71 feet (26.8%), Arakawa et al.[13] 19 of 22 feet (86%), Akita et al.[6] 2 of 38 feet (5.2%) and Govsa et al.[8] 14 of 50 feet (28%). Although the vast majority of communicating branches were usually superficial and distinct in previous studies,[7,8,12] they were deeper and thinner fascicles in the study of Akita et al.[6] and Arakawa et al.[13] In addition, Govsa et al.[8] defined four types of communicating branches, based on the course and anatomical features of the communicating branches between MPN and LPN. In our study, communicating branches between MPN and LPN were observed in 3 of 30 feet (10%). Considering the classification of Govsa et al.,[8] two of them were interpreted as type 3 (Fig. 2b) where the communicating branch was between the third common digital plantar nerve of MPN and the fourth common digital plantar nerve of LPN. The other important communicating branch was between the first common digital plantar nerve of MPN and deep branch of LPN (Fig. 2c)

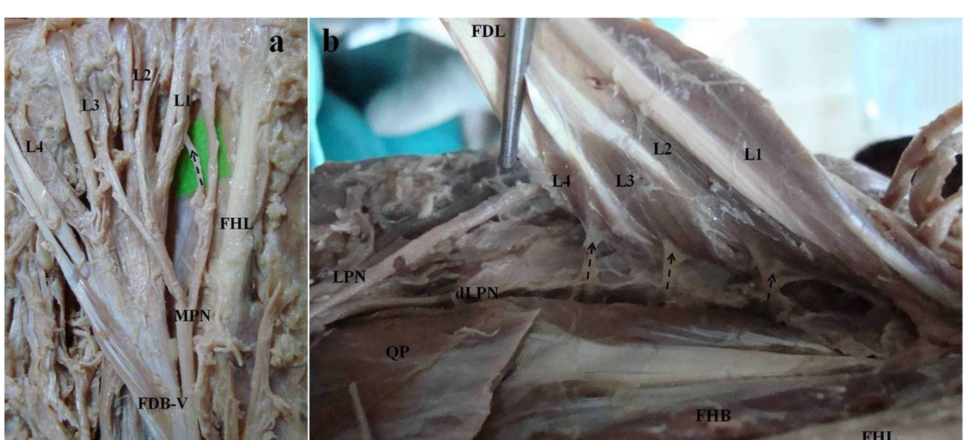

Fig. 1. The photographs show innervations of lumbrical muscles of foot. a) First lumbrical (L1) innervation. b) From second to fourth lumbrical muscles (L2-4) innervations. MPN: medial plantar nerve, LPN: lateral plantar nerve, dLPN: deep branch of lateral plantar nerve, FDL: flexor digitorum longus, FHL: flexor hallucis longus, FHB: flexor hallucis brevis, QP: quadratus plante, FDB-V: a variation of flexor digitorum brevis.

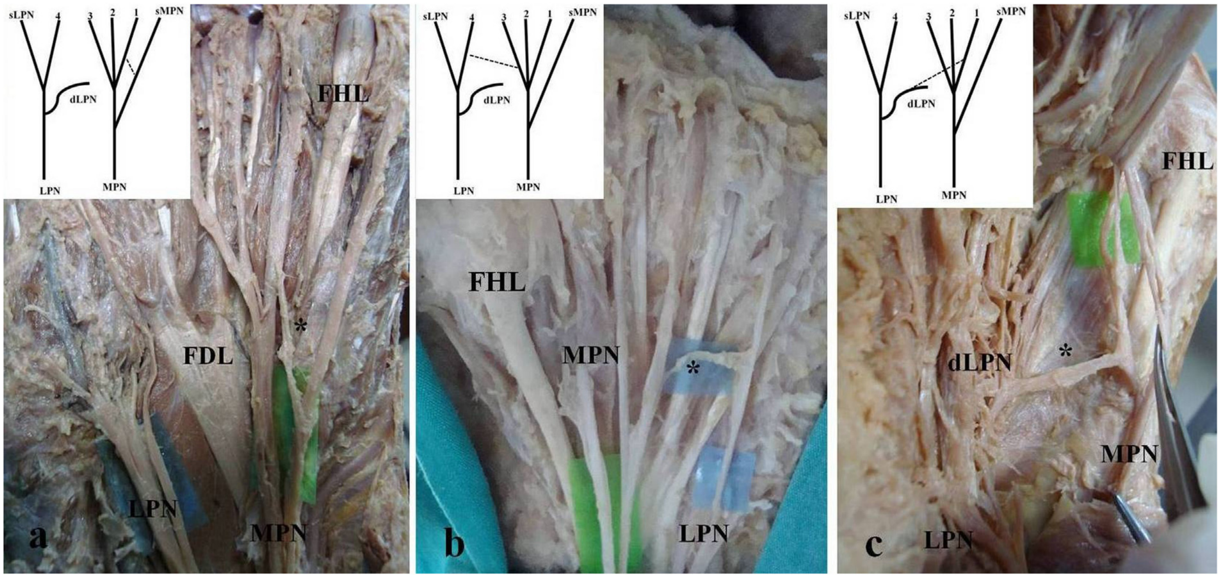

Fig. 2. The photographs and illustrations show the communicating branches between media (MPN) and lateral plantar nerve (LPN). a) Between superficial branch of MPN (sMPN) and the first common digital plantar nerve of MPN (1). b) Between the third common digital plantar nerve of MPN (3) and the common digital plantar nerve of LPN (4) c) Between first common digital plantar nerve of MPN (1) and deep branch of LPN (dLPN). FHL: flexor hallucis longus, FDL: flexor digitorum longus, sLPN: superficial branch of LPN, *: communicating branches in the photographs, Dash line: communicating branches in the illustrations, 1-4: common digital plantar nerves of MPN and LPN.

before giving branches of MPN and LPN to lumbricals. This connection did not conform to any of the types of Govsa et al.[8] and no similar case was found in the literature. Since this connection preceded the innervation of the lumbricals of the deep branch of LPN, it was likely that the fibers from MPN could function in the innervation from second to fourth lumbrical muscles. On the other hand, MPN damage such as in our case may lead to loss of function in the first lumbrical in addition to the remaining lumbricals.

5. Conclusion

Variations of the innervations of lumbrical muscles remains highly limited. Nevertheless, rare variations such as seen in our study, communicating branches in between the MPN and LPN proximal to the late distal level where they divide to the lumbrical muscles may have significance to the innervations of these muscles. Overall, our anatomical findings suggest that the innervations of the lumbrical muscles may differ from the standard pattern seen in text books. Therefore, it should be considered that MPN or LPN damage during regional surgery such as in flexor tendon transfers, flap surgery, heel pain, treatment of Morton's neuroma and hallux valgus may lead to wide range unexpected functional failures.

Conflict of interest

None.

Funding

None.

Acknowledgement

We sincerely thank to the cadavers used in the study.

References

1. Dye SF, Van Dam BE, Westin GW. Etymology and the Orthopaedic Surgeon: Onomasticon (Vocabulary). *Iowa Orthop J*. 1991;11:84–90.
2. Standring S, ed. *Gray's anatomy*. 40th ed. London: Churchill Livingstone; 2008:1453.
3. Hur MS, Kim JH, Gil YC, Kim HJ, Lee KS. New insights into the origin of the lumbrical muscles of the foot: tendinous slip of the flexor hallucis longus muscle. *Surg Radiol Anat*. 2015;37:1161–1167.
4. Brooks HS. Variations in the nerve supply of the lumbrical muscles in the hand and foot, with some observations on the innervation of the perforating flexors. *J Anat Physiol*. 1887;21(Pt 4):575–585.
5. Arakawa T, Sekiya S, Kumaki K, Terashima T. Ramification pattern of the deep branch of the lateral plantar nerve in the human foot. *Ann Anat*. 2005;187 (3):287–296.
6. Akita K, Sakamoto H, Sato T. Lateromedial and dorsoplantar borders among supplying areas of the nerves innervating the intrinsic muscles of the foot. *Anat Rec*. 1999;255(4):465–470.
7. Jones JR, Klenerman L. A study of the communicating branch between the medial and lateral plantar nerves. *Foot Ankle*. 1984;4(6):313–315.
8. Govsa F, Bilge O, Ozer MA. Anatomical study of the communicating branches between the medial and lateral plantar nerves. *Surg Radiol Anat*. 2005;27:377–381.
9. Allen S, Waerlop IF, Lardner R. The Importance of the Lumbricals. *Dynamic Chiropractic*. 2008;26(8):1–4.
10. Fiolkowski P, Brunt D, Bishop M, Woo R, Horodyski M. Intrinsic pedal musculature support of the medial longitudinal arch: An electromyography study. *J Foot Ankle Surg*. 2003;42(6):327–333.
11. Testut L. *Les Anomalies Musculaires Chez l'Homme Expliquées par l'Anatomie Comparée*. Paris, France: Leur Importance en Antropologie; 1884.
12. Levitsky KA, Alman BA, Jevsevar DS, Morehead J. Digital nerves of the foot: Anatomic variations and implications regarding the pathogenesis of interdigital neuroma. *Foot Ankle*. 1993;14(4):208–214.
13. Arakawa T, Sekiya S, Terashima T, Miki A. Pseudoganglion on the connecting branch between the deep branch of the lateral plantar nerve and medial plantar nerve. *Clin Anat*. 2011;24(5):646–651.