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Prevalence of the accessory deep peroneal nerve: A cadaveric study and meta-analysis

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ABSTRACT

Objectives: The accessory deep peroneal nerve (ADPN) is a common anatomical variant arising from the superficial peroneal nerve (SPN) and, when present, is often responsible for partial or complete innervation of the extensor digitorum brevis muscle (EDBM). The nerve lies posterior to the peroneus brevis muscle, traveling posterior to the lateral malleolus to terminate in the ankle by giving off sensory branches to the ankle and joints. Although the EDBM is usually supplied by the deep peroneal nerve (DPN), in the presence of an ADPN, electrodiagnostic procedures may be complicated. Due to the lack of detailed anatomical knowledge on the topography of the ADPN, its presence posterior to the lateral malleolus can be iatrogenically injured during surgical procedures on the ankle using a lateral approach. Therefore, this meta-analysis aimed to provide a comprehensive, evidence-based assessment of the anatomical characteristics of the ADPN, supplemented with data from our own cadaveric dissection.

Patients and methods: A comprehensive search of all major electronic databases, including Pubmed, Embase, Scopus, Web of Science, ScienceDirect, SciELO, and BIOSIS was performed. All articles with data on prevalence, symmetry and innervation of the EDBM by the ADPN were included. The anatomical data was then extracted and pooled into a meta-analysis using MetaXL 2.0. In addition, we dissected 21 cadavers (n = 42 lower limbs) bilaterally to find the ADPN.

Results: A total of 19 studies (n = 6070 lower limbs) were included in the meta-analysis. The pooled prevalence of the ADPN was 18.8% (95%CI:14.2–24.0) with a 39.3% prevalence rate for cadaveric studies. The ADPN was present more commonly unilaterally (67.0%) and when it was present, provided branches to the EDBM in 79.5% of cases. In our cadaveric study, the ADPN was identified in 5 of the 42 lower limbs dissected (11.9%); on the right side in 3 lower limbs and on the left side in 2 lower limbs.

Conclusions: The ADPN is a clinically important nerve and has been inculpated in unexplained cases of chronic ankle pain and EDBM atrophy. The variability in detection of the ADPN using electrophysiological techniques can lead to misdiagnoses of peroneal nerve lesions and increase the risk for iatrogenic injury to the ADPN, especially in laterally approaching ankle procedures and sural nerve biopsies.

1. Introduction

The accessory deep peroneal nerve (ADPN), an anatomical misnomer, is a common variant arising from the superficial peroneal nerve (SPN) [1]. The ADPN was first described in lower mammals by Ruge in 1878, however, its first description in humans can be attributed to Bryce (1896), who described it as "long muscular branch of the musculo-cutaneous nerve of the leg" and found it in 3 out of 110 legs he examined [1–4]. The anatomy of the ADPN was more extensively studied and described by Winkler in 1934, who also reported a higher prevalence of the ADPN (7 out of 19

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legs) [5,6]. The mode of inheritance of the ADPN is believed to be autosomal dominant coupled with incomplete gene penetrance, with studies showing a three times more common prevalence in members of the same family [4,7,8].

Believed to arise as a continuation of motor fibers to the peroneus longus and brevis muscles, the proximal part of the ADPN lies along the posterior border of the peroneus brevis (PB) muscle within the lateral compartment of the leg [1,3]. In the ankle, it passes posterior to the lateral malleolus, through the superior and inferior peroneal tunnels, and close to the PB tendon and the sural nerve [1,6,9]. The angulation in the course of the ADPN is believed to be due the lateral shift of the peroneal mass during early development, as it branches off from the differentiating dorsal pre-muscular mesenchyme [1,6].

The ADPN terminates in the ankle by giving off sensory branches to the ankle joints and tendons [6,10]. The sensory branches are further divided into deep and articular branches, with the deep sensory branches of the ADPN supplying the ankle joints, ligaments and dorsum of the foot [1]. The articular branches are divided into three groups, which supply the fibular periosteum, the synovial sheath of the peroneal muscles, the periosteum of the tarsal bones, and the metatarsal region, respectively [1].

The extensor digitorum brevis muscle (EDBM) extends from the metatarsophalangeal joint of the first toe to the fourth toe and participates in extending the interphalangeal joints of the second to the fourth toes. The ADPN, a clinically important nerve, usually supplies only the lateral part of the EDBM and more rarely, the entire muscle [11,12]. However, it is commonly believed that anomalous fibers from the ADPN innervate the part of the EDBM which extends the 4th toe, sometimes also the 3rd and rarely the 5th toe [1].

Although the EDBM is typically supplied by the deep peroneal nerve (DPN), when it is supplied by the ADPN, electromyographic diagnostic procedures during peroneal nerve lesions may be compromised [1]. Furthermore, a lack of detailed topographical knowledge of the nerve can leave it vulnerable to iatrogenic damage during ankle procedures using a lateral approach [6].

Even though there is a general agreement in literature that the ADPN is a common anatomical variant, there is some credence given to it being a constant structure that goes unnoticed due to poor electrophysiological detection [1,3,6]. Owing to the lack of consensus in the literature and the importance of accurate anatomical knowledge for diagnostic and therapeutic procedures, the aim of this meta-analysis was to provide a comprehensive, evidence-based assessment of the anatomical characteristics of the ADPN, supplemented with data from our own cadaveric study.

2. Materials and methods

2.1. Search strategy

An extensive search of PubMed, EMBASE, ScienceDirect, SciELO, BIOSIS, and Web of Science was performed through September 2015 to find all eligible articles to be included into the meta-analysis. No date limits or language restrictions were applied. An example of a search strategy for Pubmed is presented in Table 1. Furthermore, the references of all included articles were searched to find any other potentially eligible articles. This meta-analysis was performed by following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Appendix A) and is registered in the PROSPERO database as part of a large systematic review on the Peroneal Nerve and its branches (CRD42015026855) [13].

Table 1
Search Strategy for Pubmed.

1	((((((((((Peroneal Nerve[Title/Abstract]) OR Fibular Nerve[Title/Abstract]) OR Nervus Fibularis Communis[Title/Abstract]) OR Nervus Peronaeus Communis[Title/Abstract]) OR Fibular communicating branch[Title/Abstract]) OR External popliteal nerve[Title/Abstract]) OR lateral popliteal nerve[Title/Abstract]) OR Superficial peroneal[Title/Abstract]) OR Superficial fibular[Title/Abstract]) OR deep peroneal[Title/Abstract]) OR deep fibular[Title/Abstract])
2	((((((((((Anatomy[Title/Abstract]) OR Anatomical[Title/Abstract]) OR Variation[Title/Abstract]) OR Variations[Title/Abstract]) OR Distribution[Title/Abstract]) OR Origin[Title/Abstract]) OR Anomalies[Title/Abstract]) OR Course[Title/Abstract]) OR Division[Title/Abstract]) OR Branching[Title/Abstract]) OR Variant[Title/Abstract]) OR Variants[Title/Abstract]) OR Accessory[Title/Abstract])
3	1 and 2
4	(peroneal nerve[MeSH Major Topic]) AND (anatomy & histology OR anatomic variation[MeSH Major Topic])
5	3 or 4

2.2. Eligibility assessment

Two reviewers (J.R. and J.V.) independently assessed study eligibility for inclusion into the meta-analysis. All studies containing relevant, extractable anatomical data on the ADPN were included. Studies were excluded for being case reports, case series, letters to the editor, conference abstracts and studies which reported incomplete or non-extractable anatomical data were also excluded. Articles published in a language other than one fluently spoken by the authors, were translated by medical professionals fluent in both English and the language of the manuscript. Any differences in opinion among the authors concerning the eligibility of the studies were solved by a consensus among all the reviewers.

2.3. Data extraction

Data extraction was performed by two independent reviewers (J.V. and B.M.H.). Data on the following parameters were extracted from the included studies: prevalence of the ADPN, symmetry of the ADPN, side of ADPN, prevalence of the ADPN in cadaveric studies which supply motor branches to the EDBM and prevalence of the EDBM receiving motor branches from a present ADPN. In case of any discrepancies in data, the authors of the manuscripts were contacted via email for clarification, if possible.

2.4. Statistical analysis

Statistical analysis was performed by B.M.H. using MetaXL version 2.0 by EpiGear International Pty Ltd. (Wilston, Queensland, Australia). A random effects model was used for all analyses. To measure heterogeneity among the studies included in meta-analysis, the Chi^2 test and Higgins I^2 statistic were used. A Cochran's Q p-value of <0.10 for the Chi^2 test was regarded to indicate significant heterogeneity between studies [12]. For Higgins I^2, values of 0–40% were considered as "might not be important"; 30–60% "might indicate moderate heterogeneity"; 50–90% "may indicate substantial heterogeneity"; and 75–100% "may represent considerable heterogeneity" [14].

To probe the sources of heterogeneity, subgroup analysis by type of study, geographical distribution and side of ADPN was performed. Confidence intervals were used to determine statistically significant differences between 2 or more groups. If the confidence intervals of two values overlapped, the differences were not considered to be statistically significant [15]. Lastly, a leave-one-out sensitivity was also performed, where appropriate, to further explore the causes of heterogeneity.