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Topography of the common fibular nerve terminal division in human foetuses

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Background: *The progress of paediatric surgery and increasingly better diagnosis of foetal defects require detailed knowledge of human developmental anatomy. Precise knowledge of the anatomy of innervation of the lower extremities corresponds to this subject and is not only cognitive but also clinically important. The end of the common fibular nerve is superficially located in the area exposed to frequent injuries as well as in the area subject to possible surgical repair procedures.*
Materials and methods: *The analysis was carried out on 200 human foetuses aged from the 113th day to 222nd day of foetal life. The study material is a part of local foetal collection. The study incorporated the following methods: anthropological, preparational and image acquisition which was acquired with the use of high-resolution digital camera. Statistical analysis was carried out with the use of STATISTICA package.*
Results: *Based on the research results the new typology of the examined nerve was determined. The head of the fibula was the criterion: (i) high division — above the head of the fibula (1%); (ii) intermediate division — at the height of the head of the fibula (34%); (iii) low division — below the head of the fibula (65%). The mathematical analysis did not reveal statistically significant bilateral and gender differences. Moreover the additional branch was observed in 30% of foetuses, regardless of age class. This branch occurred in 50% of cases in both sides of the foetus. This nerve was defined as the accessory fibular nerve (nervous fibularis/peroneus accessorius).*
Conclusions: *The created unique typology of the terminal division of common fibular nerve is an important supplement to the anatomical knowledge and at the same time, due to the peripheral and superficial location of the described structures, it has a relatively high clinical significance.* (Folia Morphol 2022; 81, 1: 37–43)

Key words: common peroneal nerve, dissection, human foetuses, accessory fibular nerve

INTRODUCTION

The common fibular nerve (*nervus peroneus communis*) is formed as a branch of the sciatic nerve (*nervus ischiadicus*) at thigh level or in the area of the popliteal fossa [37, 38]. It runs in the distal and lateral direction, towards the head of the fibula. It then bends around the fibula neck (*collum fibulae*) and divides into superficial and deep fibular nerves

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(*nervus peroneus superficialis et profundus*) within the fibularis longus muscle (*musculus peroneus longus*) belly [3, 34, 38]. Both nerves, which are branches of the common fibular nerve, supply the anterior and lateral compartment of the leg and dorsal foot structures [7, 8, 38]. Many articles in the scientific literature have highlighted diseases and injuries to these nerves and their branches. One of the most common postoperative complications in the leg area is neuroma of the common or superficial fibular nerve [4, 6, 22, 32]. Damage to the common fibular nerve and its branches as a result of fibula fracture or superficial sports injuries are also frequent [1, 8, 38]. In addition, there are often various medical procedures carried out in the area near to the nerve trunk, which may cause iatrogenic damage to the nerve or its final branches [2, 19, 21, 41]. Therefore, it is of anatomical and clinical importance to know the variability of the final division of the common fibular nerve (FDCFN).

The course, branching pattern, and relationships of the common fibular nerve and its terminal branches with bony landmarks have been well demonstrated in adults by many authors [5, 11, 12, 25, 37, 38]. However, no information has yet been identified that would indicate a detailed bifurcation topography pattern in the foetus, which may be important in tumour surgery and treatment of early deformities [16, 29, 33, 36]. Therefore, the aim of this study was to develop a typology of the FDCFN in relation to the head of the fibula based on the available foetal material.

MATERIALS AND METHODS

Preparatory analysis was performed on 200 human foetuses aged from 113 to 222 days of foetal life. Foetal specimens were divided into age classes based on lunar months (Table 1).

The analysed foetal material comes from the collection of the Department of Anatomy in Wroclaw, Poland. It was obtained from maternity wards of local gynaecological clinics as a result of preterm and early deliveries and miscarriages between 1960 and 1996. The foetuses were stored in a suitable preservative solution containing ethanol, glycerol, and formalin in constant proportions [18, 31, 42]. Foetuses with visible developmental malformations and those that did not have complete clinical documentation were excluded from the study. The value of the foetal collection was confirmed in numerous previously published scientific studies [10, 13, 14, 17, 18, 24, 40]. The scientific experience of the team has been confirmed in many works using anatomical scientific methodology and anatomical techniques used for statistical analysis [9, 15, 27].

Table 1. The quantity of examined foetuses in subsequent age classes with the gender division

Calendar age [months]	N	Males	Females
4 + 5	69	34	35
6	78	39	39
7	40	18	22
8 + 9	13	8	5

The preparation was performed using classical preparatory methods. In order to visualise the FDCFN, it was necessary to use the binocular surgical microscope Leica Provido (Leica Microsystems, Germany).

The prepared common fibular nerve and its two final branches were described using schematic drawings. In addition, photographs were taken using a Sony Alpha (Sony Corporation, Japan) camera and a suitable Manfrotto (Manfrotto, Italy) tripod to ensure that the angle and height of the lens in relation to the foetuses were constant.

Statistical analysis

The mean values and standard deviations (± SD), minimum and maximum variability range were determined on the basis of the collected research material. In order to examine the independence of two qualitative features, the χ^2 independence test was applied. All analyses were performed using the STATISTICA 10.0 (TIBCO Software Inc., USA) package. The work and whole study protocol was approved by the Bioethics Committee No. KB-708/2017

RESULTS

Based on sectional studies, three types of FDCFN positions were determined. The head of the fibula was the criterion: (i) type A: high division — above the head of the fibula (Fig. 1); (ii) type B: intermediate division — at the height of the head of the fibula (Fig. 2); (iii) type C: low division — below the head of the fibula (Fig. 3). Prevalence of individual types is shown in Figure 4.

The following concepts have been introduced: symmetrical division, which means that in the case of both limbs the division of the common fibular nerve into terminal branches occurs at the same level; adjacent division, which means that from one extremity

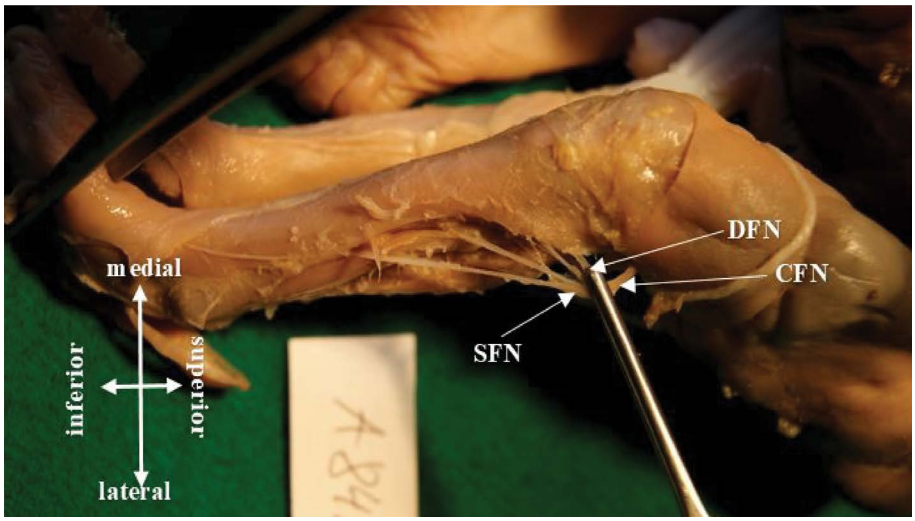

Figure 1. Type high of the common fibular nerve final division; DFN — deep fibular neve; CFN — common fibular nerve; SFN — superficial fibular nerve.

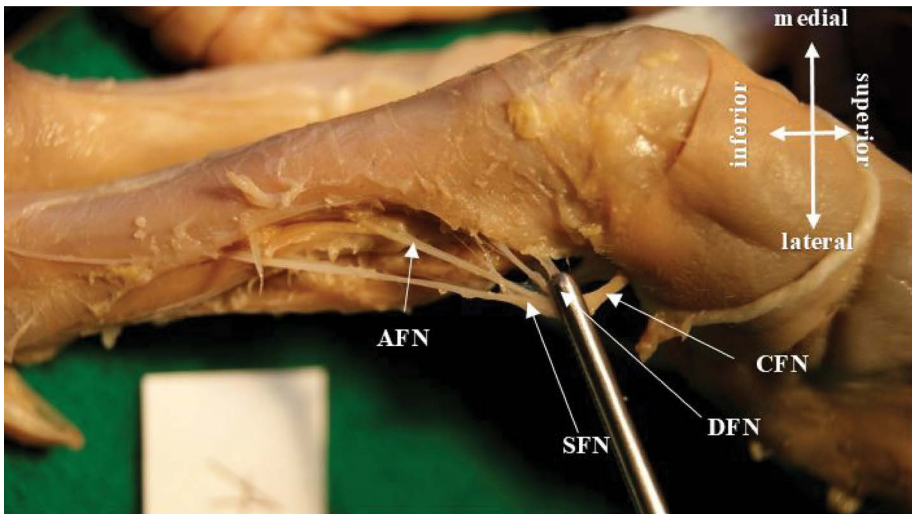

Figure 2. Intermediate type; DFN — deep fibular neve; CFN — common fibular nerve; SFN — superficial fibular nerve; AFN — accessory fibular nerve.

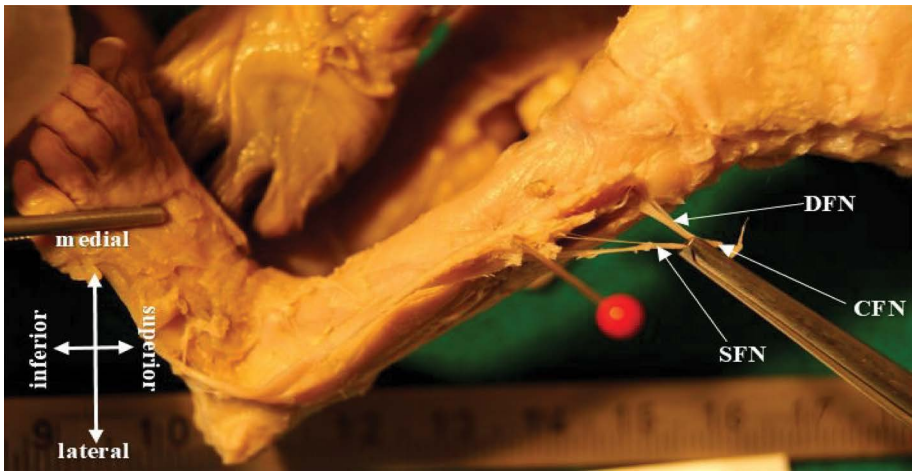

Figure 3. Low type; DFN — deep fibular neve; CFN — common fibular nerve; SFN — superficial fibular nerve.

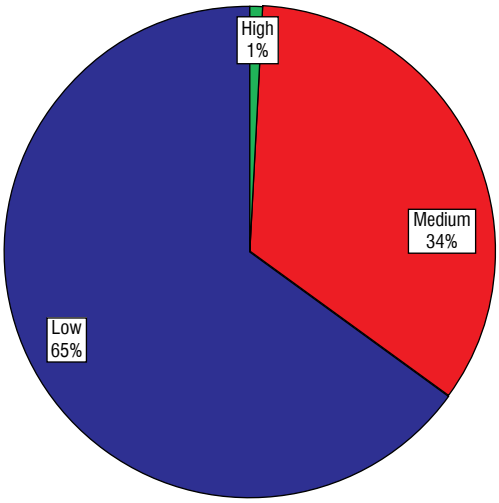

Figure 4. Percentage of individual types of end division of the examined nerve.

there is, e.g. high division, and intermediate division into the other extremity; and distant division, which refers to the extreme opposite position of the final nerve division on both limbs of one specimen (Table 2). Despite the examples of asymmetry shown (Table 2), analysis did not reveal statistically significant differences (χ^2 = 30.67, p = 0.43), which means that there are no branch variants observed more frequently in particular age classes. Additionally, there was no asymmetry in the occurrence of FDCFN branches (χ^2 = 6.67, p = 0.15) and no relationship between symmetrical/adjacent and distant division and foetal sex (Table 3).

A more detailed evaluation of the data showed no statistically significant differences in the right limb final division of the common fibular nerve (p = 0.21). Similarly, no statistically significant differences were found for the left limb (p = 0.06). A schematic drawing was also created for the right and left common fibular nerve, illustrating the course of this nerve and its division into subsequent branches.

Along with the superficial and deep fibular branches of the common fibular nerve, an additional branch was observed in 30% of foetuses, regardless of age class. This branch occurred in 50% of cases in both sides of the foetus. This nerve was defined as the accessory fibular nerve (*nervus fibularis*/*peroneus accessorius*) in a previous work [12]. Statistical analysis did not reveal any bilateral (p = 0.07) or dimorphic differences (p = 0.16) in the incidence of that additional branch of common fibular nerve in human foetuses.

DISCUSSION

The present work is based on unique material of high cognitive value [17, 23]. An important novelty of this analysis is the evaluation of variability of the FDCFN based on extensive foetal material, which is difficult to obtain. The available literature analysing the subject area is relatively poor in the case of foetal

Table 2. Frequency of occurrence of particular types of common fibular nerve terminal division (FDCFN) in selected age classes and symmetry of occurrence of given types depending on the age class

Month	A + B	A + C	B + A	B + B	B + C	C + B	C + C	Total
4 + 5	0	0	1	7	11	16	36	69
6	0	1	0	15	15	10	37	78
7	1	0	0	7	5	10	17	40
8 + 9	0	0	0	2	1	4	4	13
Total	1	1	1	31	32	40	94	200

A — high division: above the head of the fibula; B — intermediate division: at the height of the head of the fibula; C — low division: below the head of the fibula; Total — number of examined foetuses; the first letter in the first row describes the position of FDCFN on left limb, and the second one — on the right

Table 3. The relationship between symmetrical/adjacent and distant division and foetal sex (χ^2 = 9.45, p = 0.15)

Sex	A + B	A + C	B + A	B + B	B + C	C + B	C + C	Total
Male	0	1	0	13	16	15	54	99
Female	1	0	1	18	16	25	40	101
Total	1	1	1	31	32	40	94	200

A — high division: above the head of the fibula; B — intermediate division: at the height of the head of the fibula; C — low division: below the head of the fibula; Total — number of examined foetuses; the first letter in the first row describes the position of FDCFN on left limb, and the second one — on the right).

anatomy. It is based on the analysis of a small number of cases, without a division into age classes [12, 28].

It is worth emphasizing that the variability of the fibular nerves arouses great interest in the scientific world, as evidenced by numerous anatomical publications and clinical papers describing the relationship between the neurological complications of surgical procedures or injuries and the variability of the position of nerve trunks and branches [1, 4, 6, 22, 32, 37, 39]. The terminal section of the common fibular nerve trunk is particularly vulnerable to injury due to its course just above the fibula [1]. Complicated fractures or direct-acting other types of injury (blow, cut) require the implementation of surgical treatment, the success of which depends upon the anatomical competence of the performing physician in this area

For this reason, a new typology has been proposed to assess the position of FDCFN in relation to the fibula head. The head of the fibula is easily palpable in a physical examination regardless of age, and can also be easily visualised in radiological examinations. It therefore seems to be the best reference point for the final division *nervus peroneus communis.*

The proposed typology is partly inspired by a paper published by authors from South Africa, where the fibular tubercle was used as a landmark [7]. Interestingly, there is no such a structure in the anatomical nomenclature. The authors suspect that the described point is an incorrectly defined point *fibulare*, which is an anthropological determinant of the detectable fragment of *apex capitis fibulae*.

Based on the proposed typology it has been established that type 3, i.e. low division of the common fibular nerve into end branches, is the most common typology present in the population of the examined foetuses.

Very similar characteristics are presented by Turkish researchers [28] who analysed the final division of sciatic nerve and common fibular nerve based on 20 foetuses and showed relatively low nerve division in both cases. In the available literature based on adult material, the division of common fibular nerve usually takes place above the head of the fibula [3, 8, 34].

The presented data support the thesis of a different location of bifurcation *nervus peroneus communis* in human foetuses. The cause of this phenomenon has not been clearly identified. Kurtoglu et al. [28] suggest that the different location of nervous divisions is the result of limb elongation after the end of foetal development. This process affects the fascia and can thus modify the position of important anatomical points such as the final division of the common fibular nerve. On the other hand, Kołaczkowski and Stachura [26] suggest that the "climbing" of nervous divisions may be caused by a process of physical activity that significantly modifies the ratio between the length of the tendon and the length of the muscle belly by shortening the belly and lengthening the tendon, which hypothetically is supposed to change the position of the nervous branches.

Most importantly, this work aimed to demonstrate the presence of *nervus peroneus superficialis accessorius*. The available literature very rarely indicates the presence of an additional branch of the common fibular nerve [20, 35]. This additional branch occurred among as many as 30% of the examined foetuses, of which as much as 50% of the cases appeared on both sides. Similar observations can be found in a study by Domagała et al. [12], who also indicate the presence of an additional branch of the common fibular nerve, which penetrates the anterior compartment of leg in 12% of examined foetuses. The authors defined this nerve as *nervus peroneus accessorius* because of its origin, which makes it impossible to define this additional branch as an element originating from *nervus peroneus superficialis* or *nervus peroneus profundus*. The sample was much less numerous, so it is probable that this frequency would increase as the size of the examined cohort increases. While these branches are fascinating for anatomists, they are also of great clinical importance. Their unusual localisation may lead to unpredictable complications, especially as it is likely that, in addition to the sensory fibres, they may also conduct motor fibres to *musculus peroneus tertius* [14] or *musculus extensor digitorum brevis* [30].

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