

Branching patterns of the superficial fibular nerve: An anatomical study with meta-analysis

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Abstract

Purpose: To investigate variations in the branching patterns of the superficial fibular nerve (SFN) in regard to the deep fascia of the leg and to the ankle joint level.

Methods: A broad literature search was conducted in PubMed, Scopus, Lilacs, and Web of Science databases on October 14th, 2021. PRISMA guidelines have been followed throughout this review. Articles with data on SFN variations prevalence were included. The data were extracted and pooled into a meta-analysis. The authors also dissected a total of 64 formalin-fixed Brazilian fetuses (n = 124 lower limbs).

Results: Twenty-five studies (n = 1272 lower limbs) comprised this review. Concerning the SFN branching at the deep fascia, type 1 variation (the SFN pierces the fascia as a single nerve trunk) had a pooled prevalence of 86.4% (95% CI 84.5-88.2), while type 2 had a pooled prevalence of 13.6% (95% CI 11.8-15.5). At the ankle joint level, type 2 variation (the SFN splits in its terminal branches after cross the joint) was the most common pattern, with a pooled prevalence of 78.7% (95% CI 74.5-82.7).

Conclusion: In the most prevalent anatomical pattern, the SFN branching between its exit site from the deep fascia and the level of the ankle joint. These variants have great clinical significance.

Introduction

The superficial fibular nerve (SFN) supplies motricity to peroneus longus and peroneus brevis muscles [15], just as the sensibility of most of the anterolateral leg and dorsum of the foot [9]. It arises at the branching of the common fibular nerve [37] and courses through the lateral compartment of leg [33]. By piercing the deep fascia, it reaches the dorsum of the foot, branching into the medial dorsal cutaneous nerve (MDCN) and intermediate dorsal cutaneous nerve (IDCN) [9].

Several variations in the SFN branching have been reported by primary studies. These variations have a great influence on surgical procedures on the leg and foot. Knowing the anatomy of this nerve is essential to avoiding SFN injury in ankle arthroscopy [3, 31, 32]. Damage to one of its terminal branches can lead to loss of sensation in the leg skin or chronic pain in the dorsum of the foot [9]. Also, these variations have implications on the anesthetic practice, as regional anesthesia in the foot and leg may be harmed by possible nerve variations. Thus, incomplete or unsuccessful nerve blockades may occur, inflicting pain on the patient and prolonging their recovery time [6].

Understanding the SFN anatomical variations has great clinical and surgical relevance. Therefore, the purpose of the present study was to provide a comprehensive, evidence-based systematic review with a meta-analysis regarding the SFN branching patterns, supplemented with an original cadaver study.

Material And Methods

This review was first registered in the International Prospective Register of Systematic Reviews (PROSPERO; registry code: CRD42020207050) and is reported in conformity with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [19], just as the guidelines proposed by the International Evidence-Based Anatomy Working Group (iEBA-WG) [12].

Search strategy

The data were obtained through a literature survey on October 14, 2021, in the PubMed, Scopus, Lilacs, and Web of Science databases. The searches in all electronic databases comprised combinations of the keywords “superficial peroneal nerve”, “superficial peroneal nerve”, “anatomy”, and “anatomical variation”. No restrictions were imposed regarding the year of publication, language, and study design. Reference lists of the relevant articles were also searched.

Eligibility assessment

Two review authors screened the retrieved records for evaluation of eligibility. A consensus was reached among all authors to resolve any discrepancies in the study selection process. Papers were included if they assessed the SFN anatomy. Reviews, book chapters, conference abstracts, case reports or case series, and studies outside the scope of this review were excluded after the reading of abstracts and full-length texts.

Data extraction

Two review authors extracted data from the primary studies regarding its first authors' surnames, locations, years of publication, sample sizes, and case numbers of each assessed anatomical variation. Regarding the SFN branching patterns on the deep fascia, the classification system adopted was as follows: in type 1, the nerve splits after piercing the fascia; in type 2, the nerve splits before piercing the deep fascia.

With regard to the SFN branching patterns at the ankle joint level, the following classification system by Takao et al. (1998) was adopted: in type 1, both the MDCN and IDCN branching distally to the joint level; in type 2, the SFN branching proximal to the joint, but its terminal nerves branching distally to it; in type 3, the IDCN branching proximal to the joint, but the MDCN branching distal to it; in type 4, the MDCN branching proximal to the joint, but the IDCN branching distal to it; in type 5, both the MDCN and IDCN branching proximal to the joint level. These anatomical variations are represented in Fig. 1.

Statistical analysis

This meta-analysis of prevalence was performed by one review author. The random-effects model was adopted in the analyses due to the heterogeneity among the populations. Management and analysis of the data were carried out by means of MetaXL software [4], with a 95% confidence interval (95% CI) and Freeman-Tukey double arcsine transformation [10].

To measure the percentage of heterogeneity among the primary studies, Cochran's Q test and Higgins's I^2 statistic were adopted, adopting the values proposed by the iEBA-WG [12]. To assess if the geographical location has an influence on SFN anatomy, subgroup analyses were performed, by means of the chi-square test. *P*-values of less than 0.05 were deemed as statistically significant.

Dissection process

Through a longitudinal incision made along the anterior midline of the anterior region of the leg, the investigators split the skin and deep fascia and display the distal ramification of the SFN and its branches. This was done using a No. 3 scalpel handle with a No. 15 surgical scalpel blade and Metzenbaum scissors. After that, the data were collected and classified for further analysis, just as they were stored through photographic record.

Results

Study identification

The article identification process is displayed in Fig. 2. A total of 827 records were retrieved from the searched electronic databases. After removing duplicates, 720 records were analyzed, of which 57 were deemed potentially eligible after reading titles. Thirty-three studies were excluded in compliance with the exclusion criteria. A total of 24 studies were included after the selection process.

Characteristics of included studies

Twenty-four studies were retrieved by way of a literature survey [1, 2, 20–29, 5, 32, 34–36, 6–9, 13, 16, 17]. Including the current cadaveric study, 25 anatomical studies comprised this meta-analysis, with a total sample of 1272 lower limbs analyzed. The characteristics of the included studies are summarized in Table 1.

Table 1

Characteristics of the studies included in the current review. ^a C = Cadaveric, U = Ultrasound; ^b A = Adults, F = Fetuses.

Authors	n (limbs)	Location	Type ^a	Age ^b
Adkison et al. (1991)	85	North America	C	A
Agthong et al. (2008)	85	Asia	C	A
Blair e Botte (1994)	25	North America	C	A
Bowness et al. (2019)	28	Europe	C	A
Canella et al. (2009)	65	Europe	C and U	A
Canovas et al. (1996)	30	Europe	C	A
Darland et al., (2015)	50	North America	C	A
Herron et al. (1993)	20	Europe	C	A
Kosinski (1926)	109	Europe	C	A
Kurtoglu et al. (2006)	40	Asia	C	F
Ögüt et al. (2004)	63	Asia	C	A
Olave et al. (2011)	16	South America	C	A
Pacha et al. (2003)	20	Europe	C	A
Prakash et al. (2010)	60	Asia	C	A
Ribak et al. (2016)	10	South America	C	A
Rodríguez-Lorenzo et al. (2011)	9	Europe	C	A
Saito e Kikuchi (1998)	104	Asia	C	A
Şayli et al. (1998)	29	Asia	C	A
Solomon et al. (2001)	68	Oceania	C	A
Solomon et al. (2006)	68	Oceania	C	A
Takao et al. (1998)	51	Asia	C	A
Ucerler and Ikiz (2005)	30	Asia	C	A
Ucerler et al. (2007)	34	Asia	C	A
Wahee et al. (2010)	60	Asia	C	F

Anatomical dissection

There was no statistically significant association between the side of the lower limb ($p = 0.327$), or gender of the fetuses ($p = 0.142$), with the variations in SFN branching when this nerve pierces the deep fascia. About the SFN branching at the ankle joint level, no statistically significant association was also found in terms of side of the lower limb ($p = 0.834$) and gender of the fetuses ($p = 0.545$). The prevalences of variations were pooled into the meta-analysis and displayed in the forest plots.

SFN branching patterns with regard to the deep fascia

Twenty-five studies provided data on SFN branching regarding the deep fascia ($n = 1272$ lower limbs). In the worldwide population, type 1 was the most common pattern (86.4%; 95% CI 84.5–88.2; $I^2 = 92.3\%$; $p < 0.0001$). Type 2 was the least common (13.6%; 95% CI 11.8–15.5; $I^2 = 92.3\%$; $p < 0.0001$). Table 2 displays the result of the subgroup analysis for this variable. A statistically significant association was found between geographical subgroups and variations in these SFN branching patterns ($p < 0.001$), demonstrating the inequal distribution on these variations.

Table 2
Subgroup analysis of SFN branching patterns in relation to the deep fascia. Data presented as pooled prevalence (95% confidence interval).

Geographical locations	Type 1	Type 2
Asia	84.7 (81.7–87.6)	15.3 (12.4–18.3)
Europe	78.4 (73.5–83.2)	21.6 (16.8–24.5)
North America	91.3 (86.6–95.4)	8.7 (4.6–13.4)
South America	82.8 (76.5–88.6)	17.2 (11.4–13.5)
Oceania	99.6 (98.0–100)	0.4 (0.0–2)

SFN branching patterns with regard to the ankle joint level

Six studies provided data regarding the SFN branching at the level of ankle joint ($n = 389$ lower limbs). In the worldwide population, type 2 was the most common variation (61.0%; 95% CI 56.0–65.7; $I^2 = 49\%$; $p = 0.08$), followed by type 1 (21.4%; 95% CI 17.3–25.5; $I^2 = 0\%$; $p = 0.43$) and type 3 (9.4%; 95% CI 6.6–12.4, $I^2 = 0\%$; $p = 0.47$). Type 4 (5.5%; 95% CI 3.3–7.8, $I^2 = 78\%$; $p < 0.01$) and type 5 (2.7%; 95% CI 1.2–4.4, $I^2 = 59\%$; $p = 0.03$) were the least commons. Table 3 presents the result of the subgroup analysis. The global chi-square test showed non-significant differences between the frequencies observed in the different geographical subgroups assessed ($p < 0.212$).

Table 3

Subgroup analysis of SFN branching patterns in relation to the level of the ankle joint. Data presented as pooled prevalence (95% confidence interval).

Geographical location	Type 1	Type 2	Type 3	Type 4	Type 5
Asia	26 (19.2–33.4)	60 (52-67.8)	12.4 (7.6–18.3)	0.8 (0-3.2)	0.8 (0-3.4)
North America	16.1 (7.0-27.6)	61.3 (48.1–75)	6.2 (0.08–14.7)	6.2 (0.08–14.7)	10.2 (3-20.1)
South America	15.8 (10.2–23.4)	69 (60.6–77)	6.5 (2.7–11.6)	6.5 (2.7–11.6)	1.8 (0-4.8)
Oceania	23.8 (14.1–34.4)	46.7 (35.3–59)	8.9 (3-16.9)	17.5 (9.4–27.7)	3 (0-8.7)

Discussion

This study aimed to assess the SFN anatomy. The existence and pooled prevalence of two branching patterns of this nerve with regard to the deep fascia and five branching patterns concerning the ankle joint level have been reported. Knowing these anatomical variations is of great importance to avoid iatrogenic injuries to this nerve in ankle and leg surgical procedures, just as for the proper performance of regional anesthesia on the leg and foot.

SFN is the most commonly injured structure in ankle arthroscopy due to its high anatomical variability [3, 18, 32]. Considering the level of the ankle joint, type 1 and type 3 were more prevalent in Asian populations (26% and 12.4%, respectively), while type 2 was more common in South American populations (69%). Type 4 was most prevalent in populations from Oceania (17.5%), and type 5 was most common in populations from North America (10.2%). Significant differences were found between the aforementioned geographical groups. These data may indicate the need for caution when performing surgical procedures, since the SFN anatomy may vary by geography.

An important clinical application of SFN anatomy is in entrapment syndrome of this nerve. This clinical condition may occur when this nerve pierces the deep fascia to become subcutaneous at the leg distal third and is compressed by this fascia at its emergence site [17]. The basis of the symptomatology of this syndrome is due precisely to the point at which the SFN emerges from the deep fascia [30], as this is the most common site of nerve entrapment [14]. The anatomy of this nerve has a direct influence on the symptomatology and therapeutics in this entrapment syndrome. Subgroup analysis showed that type 1 was more prevalent in all geographical subgroups, with significant differences between all these groups. These data may alert to caution with fascial release procedures in patients of different nationalities.

Another important therapeutic application of SFN is for its use as a nervous graft [17, 24], although it is still underestimated for this [36]. Nervous grafts are the better option for filling the space left between proximal and distal stumps of an injured peripheral nerve. SFN provides a lengthy graft and also has a

relatively foreseeable course. Also, it can be harvested without major problems for the donor, as the lack of its sensory portion only affects the sensitivity of the dorsum of the foot [24]. Knowing the anatomical variants of this nerve ensures, in addition to better nerve utilization, a greater chance of preventing injuries to the distal branches involved in its harvesting procedure [24]. Simple electroneuromyography tests may be used for the non-invasive ascertainment of possible variations in the SFN terminal branching [11]. The preoperative application of these tests can be of great value to avoid iatrogenic injury to this nerve.

It is possible to verify SFN anatomical variations through imaging methods. In this regard, ultrasonography is of great value, as previously demonstrated [6, 7]. Certain comorbid conditions (e.g., morbid obesity, arteriopathies, or heart failure) can cause imaging obstruction by excess tissue or subcutaneous fluid. In these cases, anatomical knowledge of the SFN becomes even more vital. The primary use of this ultrasound-applied information is during the SFN local blockage technique. These groups derive the greatest benefits from the use of regional anesthesia, avoiding the harm that general anesthesia in surgical procedures can bring. Clinical and surgical practices have shown the importance of anatomical knowledge regarding the SFN location and branching for the treatment of diseases, syndromes, or injuries associated with it [6].

Declarations

Ethical approval: This study has the approval of the Human Research Ethics Committee of the Universidade Federal de Sergipe (No. 79260417.0.0000.5546).

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References

1. Adkison DP, Bosse MJ, Gaccione DR, Gabriel KR (1991) Anatomical variations in the course of the superficial peroneal nerve. *J Bone Jt Surg United States* 73:112–114
2. Agthong S, Huanmanop T, Sasivongsbhakdi T, Ruenkhwan K, Piyawacharapun A, Chentanez V (2008) Anatomy of the superficial peroneal nerve related to the harvesting for nerve graft. *Surg*

3. Ahn JH, Park D, Park YT, Park J, Kim YC (2019) What should we be careful of ankle arthroscopy? J Orthop Surg 27:1–9
4. Barendregt JJ, Doi SA, Lee YY, Norman RE, Vos T (2013) Meta-analysis of prevalence. J Epidemiol Community Health England 67:974–978
5. Blair JM, Botte MJ (1994) Surgical anatomy of the superficial peroneal nerve in the ankle and foot. Clin Orthop Relat Res United States 229–238
6. Bowness J, Turnbull K, Taylor A, Halcrow J, Chisholm F, Grant C, Varsou O (2019) Identifying the emergence of the superficial peroneal nerve through deep fascia on ultrasound and by dissection: Implications for regional anesthesia in foot and ankle surgery. Clin Anat United States 32:390–395
7. Canella C, Demondion X, Guillin R, Boutry N, Peltier J, Cotten A (2009) Anatomic study of the superficial peroneal nerve using sonography. Am J Roentgenol United States 193:174–179
8. Canovas F, Bonnel F, Kouloumdjian P (1996) The superficial peroneal nerve at the foot. Organisation, surgical applications. Surg Radiol Anat Germany 18:241–244
9. Darland AM, Kadakia AR, Zeller JL (2015) Branching patterns of the superficial peroneal nerve: implications for ankle arthroscopy and for anterolateral surgical approaches to the ankle. J Foot Ankle Surg United States 54:332–337
10. Freeman MF, Tukey JW (1950) Transformations Related to the Angular and the Square Root. Ann Math Stat 21:607–611
11. Hemmi S, Kurokawa K, Nagai T, Kushida R, Okamoto T, Murakami T, Sunada Y (2017) Variations in the distal branches of the superficial fibular sensory nerve. Muscle Nerve United States 55:74–76
12. Henry BM, Tomaszewski KA, Walocha JA (2016) Methods of Evidence-Based Anatomy: A guide to conducting systematic reviews and meta-analysis of anatomical studies. Ann Anat Elsevier GmbH. 205:16–21
13. Herron M, Langkamer VG, Atkins RM (1993) The anatomical variations of the distal course of the superficial peroneal nerve: recommendations to avoid injury during surgical procedures. Foot 3:38–42
14. Hirose CB, McGarvey WC (2004) Peripheral nerve entrapments. Foot Ankle Clin United States 9:255–269
15. Karykowska A, Rohan-Fugiel A, Mączka G, Grzelak J, Gworys B, Tarkowski V, Domagała Z (2021) Topography of muscular branches of the superficial fibular nerve based on anatomical preparation of human foetuses. Ann Anat - Anat Anzeiger 237:151728
16. Kosinski C (1926) The Course, Mutual Relations and Distribution of the Cutaneous Nerves of the Metazonal Region of Leg and Foot. J Anat 60:274–297
17. Kurtoglu Z, Aktekin M, Uluutku MH (2006) Branching patterns of the common and superficial fibular nerves in fetus. Clin Anat United States 19:621–626

18. Malagelada F, Vega J, Guelfi M, Kerkhoffs G, Karlsson J, Dalmau-Pastor M (2020) Anatomic lectures on structures at risk prior to cadaveric courses reduce injury to the superficial peroneal nerve, the commonest complication in ankle arthroscopy. *Knee Surgery, Sport Traumatol Arthrosc Springer Berlin Heidelberg* 28:79–85
19. Moher D, Liberati A, Tetzlaff J, Altman DG (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol United States* 62:1006–1012
20. Ogüt T, Akgün I, Kesmezacar H, Türker T, Uzün I, Demirci S, Marur T, Can G, Akkin SM (2004) Navigation for ankle arthroscopy: anatomical study of the anterolateral portal with reference to the superficial peroneal nerve. *Surg Radiol Anat Germany* 26:268–274
21. Olave E, Galaz C, Retamal P, Cruzat C (2011) División Alta del Nervio Fibular Superficial: Origen Precoz de los Nervios Cutáneos Dorsales del Pie . *Int. J. Morphol. scieloc*
22. Pacha D, Carrera A, Llusà M, Permanyer E, Molona O, Morro R (2003) Clinical anatomy of the superficial peroneal nerve in the distal leg. *Eur J Anat* 7:15–20
23. Prakash, Bhardwaj AK, Singh DK, Rajini T, Jayanthi V, Singh G (2010) Anatomic variations of superficial peroneal nerve: Clinical implications of a cadaver study. *Ital J Anat Embryol* 115:223–228
24. Ribak S, Fonseca JR, Tietzmann A, Gama SAM, Hirata HH (2016) The Anatomy and Morphology of the Superficial Peroneal Nerve. *J Reconstr Microsurg United States* 32:271–275
25. Rodríguez-Lorenzo A, Gago B, Pineda AF, Bhatti M, Audolfsson T (2011) Superficial peroneal and sural nerve transfer to tibial nerve for restoration of plantar sensation after complex injuries of the tibial nerve: cadaver feasibility study. *J Plast Reconstr Aesthetic Surg Netherlands* 64:1512–1516
26. Saito A, Kikuchi S (1998) Anatomic relations between ankle arthroscopic portal sites and the superficial peroneal and saphenous nerves. *Foot Ankle Int United States* 19:748–752
27. Şayli U, Tekdemir Y, Çubuk HE, Avci S, Tüccar E, Elhan HA, Uz A (1998) The course of the superficial peroneal nerve: An anatomical cadaver study. *Foot Ankle Surg* 4:63–69
28. Solomon LB, Ferris L, Henneberg M (2006) Anatomical study of the ankle with view to the anterior arthroscopic portals. *ANZ J Surg Australia* 76:932–936
29. Solomon LB, Ferris L, Tedman R, Henneberg M (2001) Surgical anatomy of the sural and superficial fibular nerves with an emphasis on the approach to the lateral malleolus. *J Anat* 199:717–723
30. Sridhara CR, Izzo KL (1985) Terminal sensory branches of the superficial peroneal nerve: an entrapment syndrome. *Arch Phys Med Rehabil United States* 66:789–791
31. Takao M, Ochi M, Shu N, Uchio Y, Naito K, Tobita M, Matsusaki M, Kawasaki K (2001) A case of superficial peroneal nerve injury during ankle arthroscopy. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc North Am Int Arthrosc Assoc United States* 17:403–404
32. Takao M, Uchio Y, Shu N, Ochi M (1998) Anatomic bases of ankle arthroscopy: study of superficial and deep peroneal nerves around anterolateral and antero-central approach. *Surg Radiol Anat Germany* 20:317–320

33. Tzika M, Paraskevas G, Natsis K (2015) Entrapment of the superficial peroneal nerve: an anatomical insight. *J Am Podiatr Med Assoc United States* 105:150–159
34. Ucerler H, Ikiz 'Z Asli Aktan (2005) The variations of the sensory branches of the superficial peroneal nerve course and its clinical importance. *Foot Ankle Int United States* 26:942–946
35. Ucerler H, Ikiz AA, Uygur M (2007) A cadaver study on preserving peroneal nerves during ankle arthroscopy. *Foot Ankle Int United States* 28:1172–1178
36. Wahee P, Aggarwal A, Harjeet K, Sahni D (2010) Surgical anatomy of sensory portion of superficial fibular nerve for harvesting nerve grafts from fetuses. *Clin Anat United States* 23:726–731
37. Watt T, Hariharan AR, Brzezinski DW, Caird MS, Zeller JL (2014) Branching patterns and localization of the common fibular (peroneal) nerve: an anatomical basis for planning safe surgical approaches. *Surg Radiol Anat Germany* 36:821–828

Figures

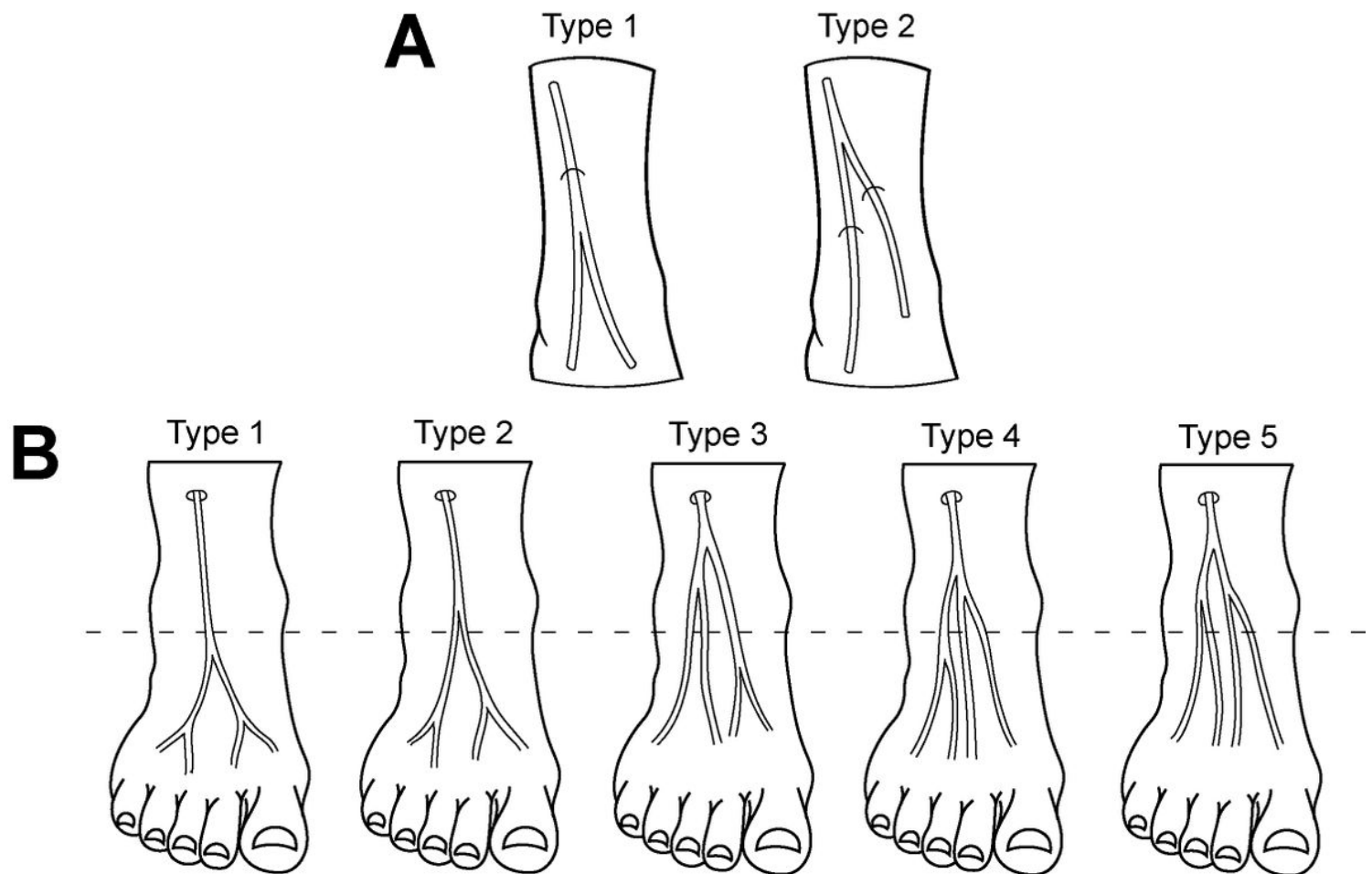


Figure 1

Branching patterns of superficial fibular nerve in relation to the deep fascia (A) and the ankle joint (B).



Figure 2

Flowchart of literature screening according to the PRISMA statement.