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Clinically important variations of deep peroneal nerve in the foot - a cadaveric study

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ABSTRACT
To trace the deep peroneal nerve in the foot and determine any variations in the relationship between the deep peroneal nerve (DPN) and dorsalis pedis artery (DPA) which will help surgeons while performing surgeries in the foot and ankle. The present study was done on 60 lower limbs from properly embalmed and formalin-fixed adult cadavers in the Department of Anatomy, Government Medical College, Kozhikode. Anatomical variations were seen between the deep peroneal nerve and dorsalis pedis artery on the dorsum of the foot. 88.3% specimen shows type 1 variation, 10% shows type 2 variation, 1.67% shows type 3 variations. The dorsal pedal neurovascular free flap contains both the dorsalis pedis artery and the deep peroneal nerve. Awareness about the DPN &DPA variant relation will help surgeons in designing a neurovascular flap in surgeries of the foot and ankle.

Keywords: Deep peroneal nerve; Dorsum of foot; Dorsalis pedis artery; anatomical variations; neurovascular flap.

INTRODUCTION

The dorsum of foot is mainly supplied by the terminal branches of the common peroneal nerve (root values: L4, L5, S1 and S2). The deep peroneal nerve (DPN) is one of the terminal branches which is widely harvested for dorsal pedal neurovascular flap along with dorsalis pedis artery. It corresponds to the posterior interosseous nerve of the forearm. The DPN passes underneath the extensor retinaculum in the ankle and reaches the dorsum of foot where it divides into medial and lateral terminal branches. The lateral terminal branch runs underneath the extensor digitorum brevis and supplies the muscle. It enlarges to form pseudoganglion and supplies the tarsal and metatarsophalangeal joints of the 2nd, 3rd and 4th toes. The medial terminal branch runs distally along with the dorsalis pedis artery (DPA) in which the nerve is lateral to the artery. The first interosseous space divides into two digital nerves that supply the adjacent sides of the great and second toes. Dorsal pedal neurocutaneous flaps are commonly used for reconstruction surgery. Good knowledge of normal variations of this nerve in the dorsum of the foot will minimize complications after surgery.(1)

Several researchers have studied the variation in the relationship between DPN and dorsalis pedis artery (DPA). Ikiz et al., in 2007, dissected 36 cadavers of lower limbs and described four different relationships between deep peroneal nerve (DPN) and dorsalis pedis artery (DPA). Type 1 - DPA is medial to DPN. Moreover, DPA is medial to the medial terminal branch (36.1%). Type 2 - On the dorsum of the foot, DPA is lateral to the medial terminal branch (25%). Type 3 - DPA and DPN cross each other at multiple levels (30.6%). Type 4 - Medial terminal branch is absent. DPA is medial to the lateral terminal branch. (2)

In 2008, Ranade et al. dissected 92 cadaver legs and described the division of DPN concerning the two malleoli. They also described the relation between the nerve and the artery and classified the following types. Type 1- DPN divides distally to the midpoint between the two malleoli (26 out of 92 specimens). Type 2- DPN divides midway between the malleoli (20 out of 92 specimens). Type 3- DPN divides into multiple branches Type 4- DPN looped around DPA (8 out of 92 specimens)[3]. Chitra et al. (2009) dissected 30 lower limbs and classified the relationship between DPN & DPA under four types, as described by Ikiz et al. in 2007. Type 1 were observed in 11 specimens (36.7%), Type 2 and 3 were seen in 9 (30%) and 8 (26.7%) specimens, respectively. Type 4 was the least common, seen in 2 specimens (6.7%).[3]

Ankle block in anesthesia includes DPN block. It is helpful in surgeries of the first web space to provide anesthesia and postoperative analgesia. Chronic pain in the anterior compartment syndrome can also be treated by DPN block. Knowing the relationship between the DPN, its terminal branches, and the DPA will help ensure safe surgical approaches in neurovascular flap surgery. It also helps in microvascular anastomosis in the reconstruction of leg. [4]

This study aims to demonstrate anatomical variations of the DPN in the dorsum of foot and its relationship with the dorsalis pedis artery.

MATERIALS &METHODS

Study behavior and ethics committee acceptance

The present study was done on 60 lower limbs from properly embalmed and formalin-fixed adult cadavers in the Department of Anatomy, Government Medical College, Kozhikode. This investigation was approved by the Institutional Ethics Committee (GMCKKD/ RP2018/ IEC/ 175).

Inclusion/ Exclusion criteria

Cadavers for undergraduate teaching and dissection classes were used for the study. Lower limb specimens with disfigurement, precluding the performance of dissection, were excluded from the study.

Dissection method

The lower limb specimen of the cadaver was placed in the supine position. Skin incisions were made on the dorsum of foot. The flap of skin and the superficial facia were reflected laterally. The DPN is identified. Its course and relation with DPA were studied.

Observation and analysis

The DPN location and its variations in the course and branching pattern were looked for and recorded. The relationship between the DPA and the DPN were studied in detail.

RESULTS

The DPN descended to the ankle and passed beneath the Extensor retinaculum. The medial and the lateral terminal branches were visualized. The relation between DPA and the DPN was classified into four types based on Ikiz et al [2] (Table 1 and Fig. 2). The relation between DPN and DPA in Type 1, Type 2 and Type 3 branches is shown in Fig. 1.

Table 1: Relation between DPN and DPA

Type	Relation	Number (Total=60)	Percentage
1	DPA is medial to DPN in the tunnel and medial to the medial terminal branch below the tunnel.	31	51.67%
2	DPA is medial to DPN in the tunnel and lateral to the medial terminal branch below the tunnel.	28	46.67%
3	DPA and DPN cross each other at multiple levels.	1	1.67%
4	No medial terminal branch was observed. DPA is medial to the lateral terminal branch.	0	0.00%

The dorsum of the right foot showed DPA medial to DPN and medial to the medial terminal branch of DPN, representing type 1. Dissection of the right foot's dorsum shows the DPN division into the medial and lateral terminal branches represents type 2. The medial terminal branch was seen crossing over the DPA. The DPA lies lateral to the medial terminal branch on the dorsum of foot. Extensor digitorum brevis, tendons of extensor digitorum longus,

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Extensor hallucis longus are visualized in Fig. 1. Dissection of the dorsum of right foot shows DPA and DPN cross each other at multiple levels represents type 3. (EDB - Extensor digitorum brevis; EDL - Extensor digitorum longus; EHL - Extensor hallucis longus; TA - Tibialis anterior; EHL - Extensor hallucis longus; EDL - Extensor digitorum longus).

Out of the 60 specimens dissected, in 31 specimens (51.67 %), Type 1 relation was observed. In these specimens, the DPA was visualized medially to the DPN in the tunnel and medially to the medial terminal branch below the anterior tarsal tunnel (Fig. 1 a). 28 specimens (46.67 %) belonged to Type 2, where the artery was seen medially to the nerve in the tunnel and lateral to the medial terminal branch below the tunnel (Fig. 1 b). 1 specimen (1.67%) belonged to Type 3, where the artery and nerve cross each other at multiple levels (Fig. 1 c). Type 4 was not observed in this study.

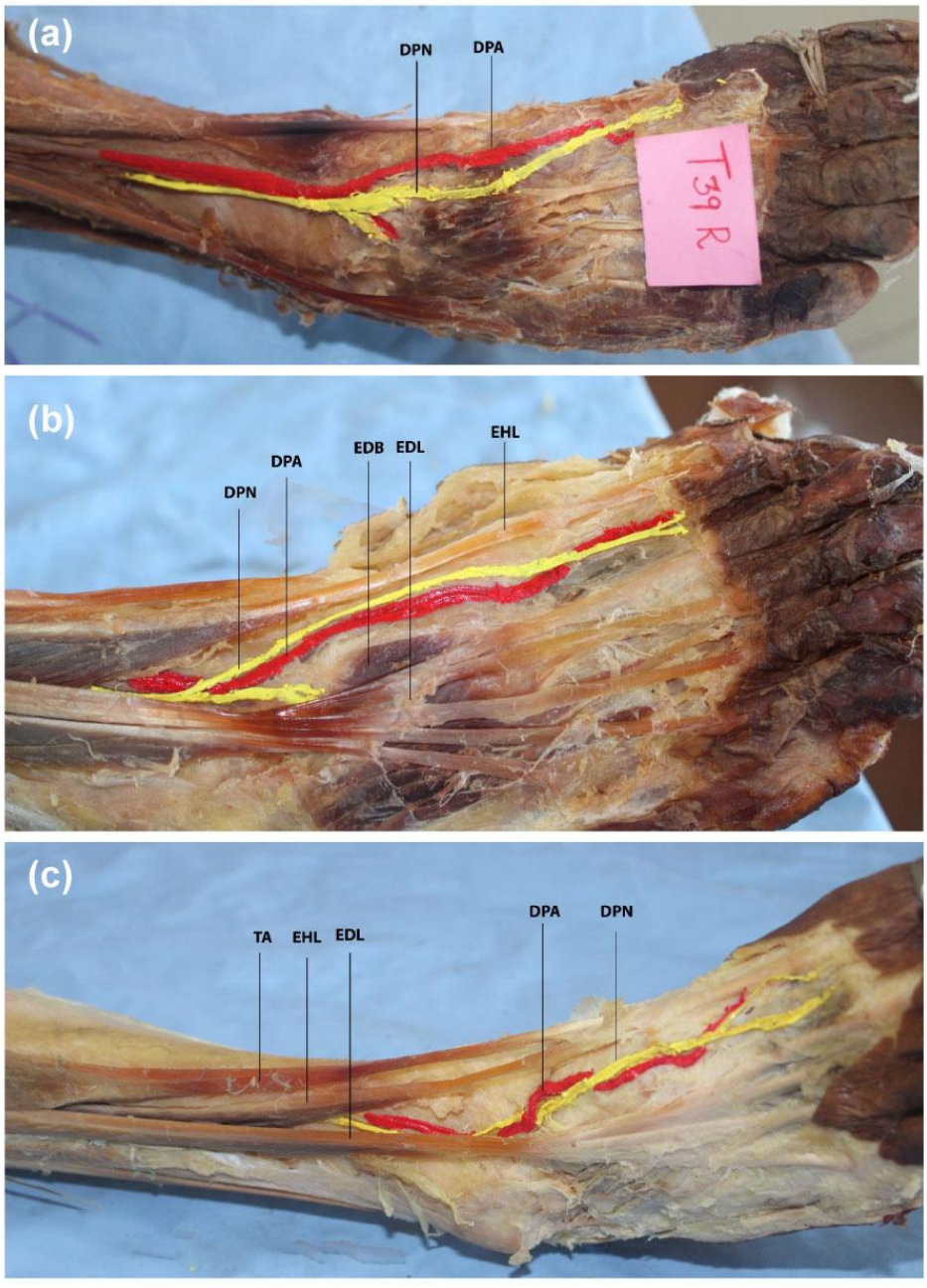

Fig. 1: Relation between DPN and DPA in (a) Type 1 (b) Type 2 and (c) Type 3 branches

4. DISCUSSION

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Variations in the relation between the DPN and its terminal branches with the DPA

At the dorsum of the foot, the DPN lies lateral to the DPA, which is the continuation of the anterior tibial artery. DPN divides into the medial and the lateral terminal branches and the classical description is that the medial terminal branch remains lateral to the DPA on the dorsum of the foot. [1]

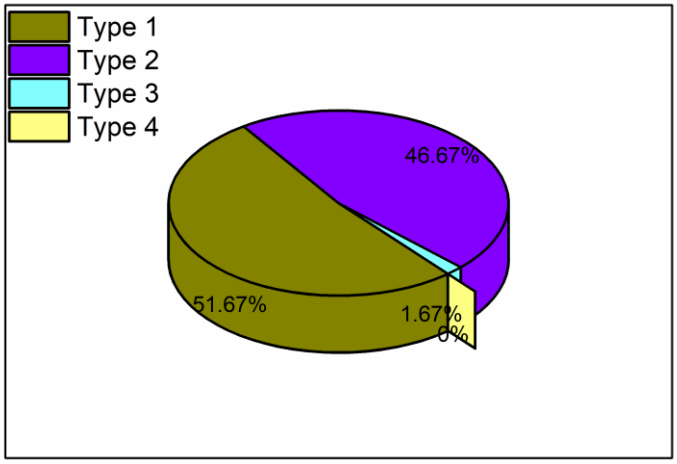

Fig. 2: Variations in the relation between DPN and dorsalis pedis artery

The variation in this relation of the DPN and its terminal branches with the DPA has been an area of interest for the surgeons in designing the dorsalis pedis neurovascular island flap, containing both the DPA and DPN. The free flap design requires knowledge of the variation in the relationship between the DPN and the dorsalis pedis artery.

In the present study, the classical relation of the medial terminal branch of the DPN and the DPA was visualized in 88.3% of the limbs. It was designated as Type 1, where the DPA is medial to the DPN in the tunnel and medial to the medial terminal branch below the tunnel (Table 2).

Studies by Ikiz et al. [2] and Chitra R [5] also concluded that Type 1, which demonstrated the classical relation, was indeed the most common relationship, but the percentages of observations were still lower to 36.1% and 36.7% of the limbs dissected. The discrepancy in percentages compared to the previous studies is probably because of the sample size, where the present study had dissected 60 limbs compared to 36 and 30 limbs by Ikiz et al. [2] and Chitra R et al. [5], respectively.

In the present study Type 2 was observed in as much as 10 % of limbs, where the DPA was lateral to the medial terminal branch below the anterior tarsal tunnel (Table 2). In the present study Type 3 was observed in one specimen (1.67%), where DPN and DPA cross at multiple levels (Table 2).

Table 2: Relationship between DPN with the DPA- a comparison between the present study and previous studies

Author	Total limbs	Relation of DPN & DPA (All values are expressed in % of the limbs dissected)			
		Type 1	Type 2	Type 3	Type 4
Ikiz et al.	36	36.1	25	30.6	-
Chitra R et al.	30	36.7	30	26.7	6.7
Present study	60	88.3	10	1.67	-

The presence of this variation in the relation of the DPA with the medial terminal branch of the DPN, where the DPA might lie lateral to the medial terminal branch, should be kept in mind to ensure safe surgical approaches in neurovascular approaches in neurovascular flap surgery and surgical release in anterior tarsal tunnel syndrome. The knowledge of the variant relation between the artery and the nerve also helps in microvascular reconstruction of the leg.

The existence of the variation mentioned above emphasizes the importance of using a nerve stimulator or ultrasound-guided deep peroneal block to localize the nerve and avoid injury to the artery. Especially in obese patients, using ultrasound imaging to identify this anomalous relation and to view the needle movements in real-time will be worthwhile.

Clinical significance of the relation of the DPN with DPA

Ankle blocks were commonly performed for surgical anesthesia and postoperative analgesia for procedures involving the foot, as cited by Christian R. Falyar [6]. In mid and forefoot surgeries, especially in bilateral cases, performing an ankle block have significant advantages over more

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proximal peripheral nerve blocks. It is also significantly more straightforward, safe and cost-effective, provides better postoperative analgesia, and decreases morbidity than general or spinal anesthesia. [4,7,8]

Surgery in the foot involves blocking the DPN at the ankle level. Though anesthetists use a nerve stimulator for performing sciatic nerve blocks routinely, blocks at the ankle level were performed by anatomical knowledge alone without using a nerve stimulator. [9]

As Kopka et al. [10] described, both the superficial peroneal nerve and the deep peroneal nerves were blocked on the dorsum of the foot. The position of DPA is ascertained by palpating its pulsations below the line joining the medial and lateral malleoli. Medial to the pulsation of the artery, a 25 G needle was introduced. Once the needle is advanced and it rests on the bone, a local anesthetic was injected.

Chitra R [5] cited awareness about the variant relation of the DPN &DPA is also necessary for surgeons in designing a neurovascular free flap in surgeries of the foot and ankle. Ma et al., in their study, suggested a single anterolateral incision approach for distal tibia and fibula. It is a practical and straightforward approach to treating distal tibia and fibula fractures. [11,12]

Anterior tarsal tunnel syndrome is a condition similar to the tarsal tunnel syndrome, but here, unlike the tibial nerve's involvement, it is the DPN that was compressed. [13] Relation between the terminal branches and the adjoining DPA is essential to the operating surgeon to perform an effective procedure for treating refractory cases of anterior tarsal tunnel syndrome. The knowledge of variations will help the radiologists perform neurological imaging for preoperative diagnosis of the causes of anterior tarsal tunnel syndrome.

5. CONCLUSION

The anatomical variations in the relation between the DPN and its terminal branches with the DPA were studied. There are variations observed in the relationship between terminal branches of DPN and DPA in the dorsum of the foot. In the present study, the classical relation of the medial terminal branch of the DPN and the DPA was visualized in 88.3% of the limbs (Type 1), Type 2 was observed in 10 % of limbs, type 3 was observed in one specimen (1.67%). Knowledge of the different DPN courses and their terminal branches is essential to reduce the risk of iatrogenic injury during orthopaedic foot and ankle surgery. Hence awareness about the relationship between the DPA and the DPN at the dorsum of the foot assumes significance.

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