

THE RELATIONSHIP BETWEEN THE DEEP FIBULAR NERVE AND THE DORSALIS PEDIS ARTERY IN THE ANTERIOR TARSAL TUNNEL: A CADAVERIC STUDY

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ABSTRACT

The aim of the study was to demonstrate the relationship between the deep fibular nerve (DFN) and the dorsalis pedis artery (DPA) in the anterior tarsal tunnel (ATT) in order to provide useful anatomical knowledge for safe surgical approaches of the foot and ankle. 40 formalin fixed lower limbs were dissected and examined. The level of bifurcation of the DFN in ATT was noted. Relationship between the DFN and DPA was examined and recorded. The location of the DFN bifurcation was within the ATT in 34 specimens (85%) and was distal to the tunnel in 5 specimens (12.5%) and in one specimen (2.5%) there was bifurcation was observed proximal to the tunnel. Three distinct types of relationship were noted between the DFN and DPA. We believe that the detailed anatomical knowledge of the DFN, DPA and ATT will help during planning the surgical approaches of foot and ankle and help in diagnosis of clinical syndromes related with peripheral nerves of the foot.

Key words: Ankle, Arteries, Foot, Foot deformities, Peroneal nerve, Tarsal tunnel syndrome

INTRODUCTION

Anterior tarsal tunnel (ATT) is a fibro-osseous tunnel roofed by the inferior extensor retinaculum and the floor is formed by the fascia overlying the talus and navicular bone (Chitra R, 2009). The tunnel contains four tendons, the dorsalis pedis artery (DPA), a vein and deep fibular nerve (DFN) (Andersen BL et al., 1992). DFN is the main nerve of the anterior compartment of the leg. It enters the anterior tarsal tunnel piercing the anterior intermuscular septum along with anterior tibial vessels. It enters the foot lateral to (DPA). It immediately divides into medial and lateral terminal branches. The medial terminal branch runs on the dorsum of the foot lateral to DPA along the dorsum of the foot. In the forefoot it passes deep to the extensor hallucis brevis tendon and ends by supplying the first web space and adjacent sides of great toe and second toe. The lateral terminal branch passes in front of the ankle deep to the extensor digitorum brevis, enlarges as

pseudoganglion and supplies the muscle (Standing S et al., 2005).

The DFN exhibits considerable variations in its course it can be injured because of trauma, iatrogenic causes or mechanical irritation (Lawrence SJ and Botte MJ, 1995). Iatrogenic injury may result from surgical procedures and arthroscopy on the foot and anterior ankle regions. Compression of DFN beneath the extensor retinaculum of the ankle causes anterior tarsal tunnel syndrome (ATTS), characterized by pain, weakness and sensory changes in foot and ankle (Di Domenico LA and Masternick, 2006; Miliam PB and Basse PN, 2009). Damage to the deep fibular nerve causes loss of dorsiflexion of the ankle causing foot drop, weakening of inversion and loss of extension of metatarsophalangeal joint (Romanes GJ, 2011).

Submitted 31st May 2016. Published online 1st October 2016. To cite: Jain RA, Tejaswi HL. The relationship between the deep fibular nerve and the dorsalis pedis artery in the anterior tarsal tunnel: a cadaveric study. *Anatomy Journal of Africa*. 5: 811 -816

Blocking of the medial branch of DFN is an effective, simple and long lasting treatment in cases of nocturnal leg cramps sustained as a result of lumbar spine surgery (Imura T et al., 2015). Neurotomy of the branches of the DFN to the extensor hallucis longus and extensor digitorum longus is an effective treatment for extensor dystonia of the great toe and/or other toes (Allart E et al., 2015).

The dorsalis pedis neurovascular flap contains both the DFN and the DPA (Ohmori K and Harii K, 1976; Cho BC et al., 1998). The extensor digitorum brevis muscle flap is used as a free or local flap. This muscle gets arterial supply from DPA and motor innervation by deep fibular nerve. Dorsalis pedis flap is being widely used for reconstructive surgeries of the eye socket, intra-oral, palm and hand reconstruction (Daniel RK et al., 1976; Strauch B et al., 1990; Dong JS et al., 2003) Because this flap contains the DFN and the DPA, both these anatomical structures

have importance in flap surgery (McCraw MJ and Furlow LT, 1975; Tang YB et al., 1990)

The anatomical variations of the peripheral nerves occur with variable frequencies in the population. Awareness of such anomalies/variations is of importance to avoid misdiagnosis of clinical syndromes and to prevent complications associated with surgeries. Very few studies are available in Indian literature about the detailed anatomy ATT, DFN and DPA. With this background we designed a cross sectional study involving dissection of the ankle and foot region of cadavers and examination of the DFN and DPA in the ATT. The aim of our study was to describe the distinct relationship between DFN and DPA in the anterior tarsal tunnel so that the frequency of these variations can be kept in mind by the surgeons to ensure safe surgical approach during the reconstructive surgeries and also to design the neurovascular flaps.

MATERIALS AND METHODS

this was a cross Sectional Study descriptive **carried out at the** department of Anatomy. Both the Lower limbs of 20 formalin fixed cadavers in the Department of Anatomy. The location of DFN and DPA was noted with respect to the anterior tarsal tunnel in 40 lower limbs. The branching pattern of DFN and relation of the branches to the DPA was noted. Dissection of 40 formalin fixed foot and ankle specimens was carried out after obtaining clearance from the institutional ethical committee. Twenty specimens were from right lower limb, and twenty were from left lower limb. All specimens were dissected with ankle in the mild equinus decubitus and measurements were completed.

A longitudinal incision was started from a point just lateral to the tibial crest and the same was extended to the anterior aspect of the ankle, continued across the midfoot, and ended within the first web space. The deep fascia of the leg was incised parallel to the cutaneous incision. The DFN and the anterior tibial vessels were identified proximally. The nerve and its branches were dissected and traced from in proximal-to distal direction. The inferior extensor retinaculum was removed and DFN along with DPA was identified within the anterior tarsal tunnel. The DFN and the artery with their terminal branches were dissected carefully in a proximal to distal direction and the relationship was observed and recorded.

RESULTS

The location of the DFN bifurcation was within the anterior tarsal tunnel in 34 specimens (85%) and was distal to the tunnel in 5 specimens (12.5%). Sidewise distribution of the relationship

of branching of DFN with respect to the anterior tarsal tunnel is shown in table 1. In one specimen (2.5%) there was bifurcation was observed proximal to the tunnel. This type of

proximal bifurcation was observed in specimen of left foot and ankle. The medial terminal branch in all the specimens was terminating by the supplying the web space between the first and the second toe.

The DPA was medial to the DFN in the anterior tarsal tunnel in 31 (77.5%) specimens. In 9 (20%) specimens the artery and nerve crossed each other at multiple levels within the anterior tarsal tunnel. Within the tunnel three distinct relationships of the DFN with DPA was observed.

Type 1: The DPA was medial to the DFN in the anterior tarsal tunnel. The artery was medial to the medial terminal branch of the DFN distal to the tunnel. This pattern was observed in 22

(55%) specimens. This type was seen in right side in 17 (85%) and on left side in 5(15%).

Type 2: The DPA was medial to the DFN in the anterior tarsal tunnel but the artery passed lateral to the medial terminal branch of the deep fibular nerve. This pattern was recorded in 9 (22.5%) of the specimens. The pattern was observed on left side in 8(88.9%) and on right side in only one (11.1%) specimen.

Type 3: The DPA crossed over the DFN at multiple intervals in the anterior tarsal tunnel. Distal to the tunnel the artery was medial to the medial terminal branch. This pattern was noted in 9 (22.5%) of the specimens. This pattern was observed only left sided specimen.

Table1: Bifurcation of DFN with respect to anterior tarsal tunnel

	Bifurcation of DFN with respect to anterior tarsal tunnel		
	Within the Tunnel Number(percentage)	Distal to the Tunnel Number(percentage)	Proximal to the tunnel Number(percentage)
Right foot and ankle	19 (47.5%)	02 (5%)	00
Left foot and ankle	15 (37.5%)	03 (7.5%)	01 (2.5%)
Total	34 (85%)	05 (12.5%)	01 (2.5%)

Table 2: Comparison of prevalence of relationship between DFN and DPA in the anterior tarsal tunnel

SI no	Authors	Number of specimens dissected	Prevalence of Relationship between DFN and DPA (%)			
			Type 1	Type 2	Type 3	Type 4
1	Ikiz et al	36	36.1%	25%	30%	8.3%
2	Chitra R	20	36.7%	30%	26.7%	6.7%
3	Present study	40	55%	22.5%	22.5%	0

DISCUSSION

Variations in the anatomical course, branching pattern and relations of DFN have been described with considerable variations in the existing literature. Findings of our research confirm wide range of variability in the anatomy of DFN and differ only slightly from previously described studies.

The location of bifurcation of DFN has been reported to be 86% within the anterior tarsal tunnel, in 5.6% distal to the tunnel and no bifurcation in 8.3%.^{2, 20} In our study, the bifurcation of the DFN was observed within the anterior tarsal tunnel in 85% of the specimens, distal to the tunnel in 12.5% of the specimens and in 2.5% the termination was distal to the tunnel. In all the specimens the bifurcation of DFN was noted. None of the specimens showed absence of branching pattern as described by previous studies. However our research showed one (2.5%) specimen had bifurcation proximal to the tarsal tunnel and this variation has not been described in earlier studies. This variation could be because of the decubitus of mild equines of the ankle we used while dissecting.

The relationship of DFN with DPA in the anterior tarsal tunnel has been classified into four types (type 1, 2 and 3 are described in results) by various authors (Andersen BL et al., 1992; Ikiz AZA et al., 2007). In type 4 there is absence of bifurcation of the DFN and hence absence of its medial terminal branch. In our study wide range of variations were observed in the pattern of relationship between the DFN and DPA. The prevalence of these types as reported in previous studies is shown in the table 2.

We did not observe the type 4 pattern of DFN relationship with the DPA. All 40 specimens showed bifurcation of the deep fibular nerve. And in all the specimens the first web space of

the foot was supplied by the medial terminal branch of the deep fibular nerve. No communication/anastomosis was observed between the DFN and the superficial peroneal nerve. DPA absence was also not observed in our research compared to studies done by above mentioned authors.

Clinical considerations: DFN injury results in a variety of clinical symptoms depending on the type of injury and location. Nerve injury can be caused by trauma, mechanical irritation, iatrogenic injury, and compression from soft tissue and osseous anomalies (Lawrence SJ and Botte MJ, 1995). DFN injury results in a clinical symptoms ranging from tingling sensation, weakness of muscles, severe pain weakness of inversion and loss of extension of metatarsophalngeal joint. Iatrogenic causes of DFN injury include the arthroscopic procedures of the ankle and the reconstructive surgeries. Prior knowledge of anatomy and variations of the DFN and DPA helps in better planning of the surgical/arthroscopic procedures and hence minimizing the complications associated with these surgeries. It also reduces the risk of iatrogenic injuries to the DFN and/or DPA.

ATTS prevalence is rare because high index of suspicion is required for the diagnosis, especially when dealing with chronic cases. Major etiologic factor in ATTS is compression of the DFN and its branches under the inferior extensor retinaculum. Symptoms of ATTS can be relieved by decompression of inferior extensor retinaculum (Gani N et al., 2015). The risk of entrapment neuropathy increases especially with type 3, where DFN and DPA crosses over at multiple levels under the ATT. Since branching of DFN occurs at proximal part of the ATT decompression of the ATT can be performed at more proximal level at the inferior extensor retinaculum.

Recent evidences show blocking of the medial terminal branch of the DFN at ATT is an effective

and simple treatment of chronic nocturnal leg cramps caused after lumbar spine surgery. However mechanism of pain reduction caused by blockade of the medial terminal branch of the DFN still remains unclear (Imura T et al., 2015). Identification and injection of the anaesthetic requires palpation of DPA pulsations and so that the drug can be administered medial to the DPA. DFN neurotomy in the ATT is reported to be an effective treatment of dystonia of the extensor hallucis longus and extensor digitorum longus (Allart E et al., 2015). DFN neurotomy requires a detailed knowledge of the branching pattern of the DFN and its relation to the DPA.

In conclusion operative procedures of the foot and ankle including reconstructive surgeries require the detailed knowledge about the anatomy of DFN and DPA to avoid iatrogenic injuries to the DFN and the DPA. Hence identification of the DFN and its Branches and its relation to DPA is essential before exploring the foot and ankle region. Thus the data provided in this study can provide useful anatomical knowledge for the surgeons during the surgical approaches to the foot and ankle.

Acknowledgements: The authors wish to acknowledge the Short Term Studentship (STS) Program of Indian Council for Medical research (ICMR) under which the research was carried out.

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