THE SIZE, BRANCHING PATTERN AND ANATOMICAL RELATIONSHIPS OF THE THE DORSAL PEDAL ARTERY ON THE DORSUM OF THE FOOT: A CADAVER STUDY

L van der Merwe, N Briers, MC Bosman

Department of Anatomy, School of Medicine, Faculty of Health Sciences, University of Pretoria

Introduction

Surgical techniques such as ankle arthroscopy and reconstructive flap surgery have made detailed knowledge of the dorsal pedal artery (DPA) and the deep fibular nerve (DFN) on the foot dorsum essential.[1] During reconstructive surgery involving the leg, various flaps are obtained from the leg and dorsum of the foot as donor sites. These flaps are then transplanted to the required donor site to improve the function and form of the particular body part.[2] A sufficient anatomical knowledge of the donor site is essential to ensure that the blood vessels resected with the free flap is correctly severed to enable the necessary microsurgical procedures at the recipient site.[3]

The DPA is the major blood supply to the dorsum of the foot, while the DFN is the main motor nerve to the anterior muscles of the leg and dorsiflexors of the feet and toes.[4] The anterior tibial artery gives rise to the DPA at the level of the ankle joint, halfway between the malleoli. It therefore runs from between the malleoli with the DFN, deep to the inferior extensor retinaculum (IER) between the extensor digitorum longus tendons on the dorsum of the foot and the extensor hallucis longus tendon.[4] The DFN is derived from the common fibular nerve at the lateral aspect of the fibular neck.[5]

For an effective flap, it is very important that vascularization and innervation is secured. Thus, these structures must be preserved during surgery. Although some studies include aspects of the relationship between the DPA and DFN, there is a lack of knowledge on the size, branching pattern and exact relationship of the DPA and DFN to more constant landmarks, such as the inferior extensor retinaculum. Some authors also describe the termination of the DPA as a bifurcation rather than a branching into its terminal branches.[6] This has been debated in literature and is a potentially confusing description that may impact the understanding of surgical procedures.

Aims

The aims of this study were to document the DPA and DFN and their relation to the IER, in order to describe the variations in the distribution of both the artery and nerve. The size of the DPA and its branches were measured and the branching pattern was noted to determine the correctness of the term "bifurcation" in the description of the termination of the DPA.

Materials and Methods

Forty cadaver ankles were dissected on both sides in both sexes in the Department of Anatomy, School of Medicine, University of Pretoria after obtaining ethical clearance from the Main Ethics Committee of the University of Pretoria. The protocol (25/2009) was accepted and cleared for the dissections under the Human Tissue Act 65 of 1983.

The dissections were performed to expose the contents of the anterior tarsal tunnel and to document the DPN and DPA and their relative branches. The relationships of the DPA to the DFN as well as the branching pattern of the DPA in relation to the IER were then noted. The size of the DPA and branches were measured at the level of the inferior extensor retinaculum (IER) with a Vernier caliper (accuracy of 0.01mm).

The frequency and percentage was used to describe the relationship and variations between the DFN and DPA. During the statistical analysis, comparisons were made between the various groups: Males vs. female and age groups. In case of the latter, cadavers were divided in 2 age groups: 20 - 49 and above 50 years.

Results

The distal branching level of the DPA and DFN was investigated in relation to the IER as the fixed point. The results are presented in Tables 1 and 2.

Table 1: The distal branching level of the DPA in relation to the IER

Position to IER	n	% Prevalence
Proximal	1	2.5
Deep to	23	57.5
Distal	15	37.5
Absent	1	2.5
Total	40	100

Table 2: The level of distal bifurcation of the DFN in relation to the IER

Position to IER	n	% Prevalence
Proximal	11	27.50
Deep to	22	55.0
Distal	7	17.50
Total	40	100

The level of the distal branching for the DPA was investigated in all 40 limbs with the IER as the fixed level. As seen from table 1, the majority of distal branching occurs deep to the IER (57.5%).

The level of the DFN bifurcation in relation to the IER was again determined for 40 limbs. From table 2, it is clear that most of the bifurcations occur deep to the IER (55.0%). In 17.5% the bifurcations of the nerve occurred distal to IER, while 37.5% of the arteries branched distal to the IER.

The distance between the distal bifurcation of the DFN and distal branching of the DPA varied significantly with the average distance being 7.79mm ± 2.9. No significant difference was observed when comparing male and female cadavers or the different age groups (T-test, p>0.05).

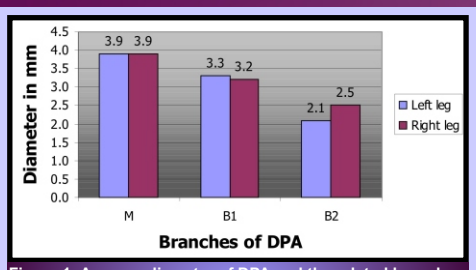

Figure 1: Average diameter of DPA and the related branches after the distal branching (n = 20). M: the main branch of the distal DPA prior to branching; B1: the 1st and most medial branch of the DPA; B2: the 2nd and most lateral branch of the DPA.

The size of the DPA and branches at the distal point after the level of the inferior extensor retinaculum (IER) are presented in figure 1.

As seen from Figure 1, the DPA has 2 branches at the most distal branching level. The 1st branch (often the medial branch) is compared to the 2nd branch (often the lateral branch) in relation to the average diameter to determine whether the term bifurcation can be used in terms of the most distal branching. The diameter of the left 1st branch (medial branch) is 3.29mm ± 0.2 while the 2nd branch (lateral branch) has an average diameter of 2.06mm ± 0.1. The average diameter of the right 1st branch (medial branch) was determined at 3.23mm ± 0.2, while the 2nd branch (lateral branch) was measured at 2.46mm ± 0.2 (lateral branch). In general, the 1st branch or medial branch was significantly thicker than the 2nd or lateral branch (T-test, $p < 0.05$).

Discussion

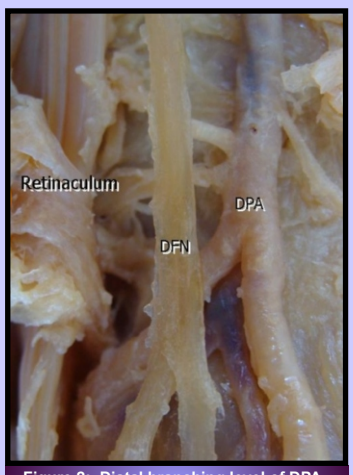

Figure 2: Distal branching level of DPA as seen in the majority (57.5 %) of cadavers in the study

The level of distal branching of the DPA is of great importance in surgery related to the ankle and dorsum of the foot. Four main categories of the distal branching of the DPA have been identified as seen in table 1. The main occurrence of the branching level of DPA is deep to the IER. This occurs in 57.5% of the cases, followed by 37.5% of the cases where the distal branching occurs distal to the IER. In 2.5% of the investigated specimens the distal branching was proximal the IER and in 2.5% the distal branching of the DPA is completely absent.

The bifurcation level of the DFN can be classified into three categories as seen in table 2. The bifurcation of the DFN is similar to the distal bifurcation of the DPA as the majority 55% was located deep to the IER. In 27.5% of the investigated specimens the bifurcation occurs proximal the IER and in 17.5% it was observed distal to the IER.

In figure 4 it can clearly been seen that the majority (55.0%) of the branching levels of the DPA and DFN are located deep to the IER. This is highly significant when reconstructive surgery of the leg and foot is performed. When a free flap is harvested, the neurovascular supply is removed with the tissue flap to ensure adequate neurovascular supply at the recipient area.

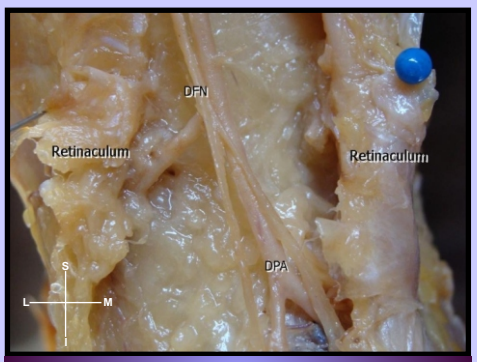

Figure 3: The bifurcation of the DFN was most often (55%) encountered deep to the IER.

It cannot be assumed that the distal branching of the DPA and the bifurcation of the DFN occurs on the same level, or that it should be closely associated. Although the average distance between the distal branching of the DPA and the bifurcation of the DFN was determined as 7.79mm ± 2.9, the range can extend from 0.5mm to 22.2mm. This should be duly noted in procedures related to the leg and dorsum of the foot and could result in ineffective reconstructive surgery.

Various branching pattern variations of the DPA were noted and categorized in terms of its relation to the DFN and IER. It was noted that the DPA gives rise to several branches prior to its distal termination point. These branches were commonly found in the vicinity of the IER.

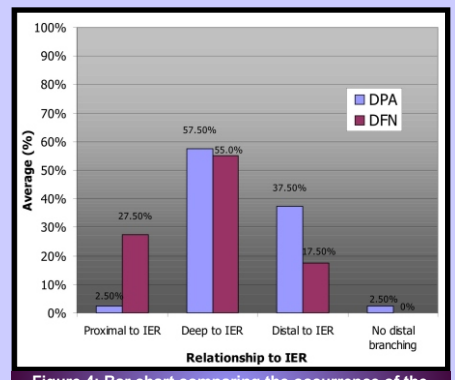

Figure 4: Bar chart comparing the occurrence of the distal branching of the DPA and the bifurcation of the DFN in relation to the IER.

It can occur proximal, deep to or distal to the IER and can therefore be described in 3 categories. In 62.5 % of the observed cases, branches of the DPA were found deep to the IER as seen in figure 5. In 27.5% of the cadavers the branches were found proximal to the IER, while 10% of the branches were found distal to the level of the IER. No significant difference could be demonstrated between the sexes (T-test, $p > 0.05$).

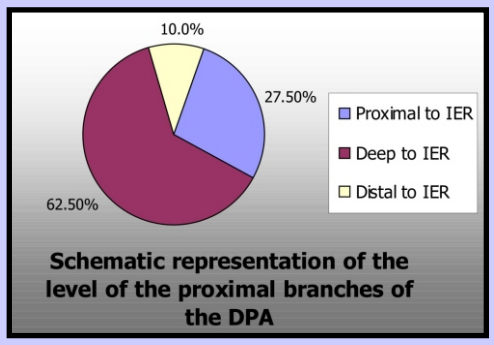

Figure 5: Pie chart indicating the level of branching of the DPA prior to its distal termination point.

The term 'bifurcation' is often used to describe the distal branching of the DPA. In this study the distal branches of the DPA was measured to determine whether the artery branches into equal portions. The mean diameter of the branches, presented in table 1, indicates that the diameter of the left 1st branch (medial branch) as 3.29mm while the 2nd branch (lateral branch) has an average diameter of 2.06mm. The average diameter of the right 1st branch (medial branch) was determined at 3.23mm while the 2nd branch (lateral branch) was measured as 2.46mm. From these measurements it can clearly be seen that both the branches of the artery are not of the same diameter, therefore the term bifurcation cannot be used. The difference was also statistically significant (T-test, $p < 0.05$). In order for the term 'bifurcation' to be used the arterial diameter should be of equal value indicating that the artery divides into equal sized branches, which was not the case in our study.

Several interesting observations were made during the course of the study: In some cases the DPA first forms a trunk when branching, after which the trunk branches to form the various smaller arteries. The trunks that are part of the arterial branching are normally greater diameter than the main DPA. The trunks can directly split into the various arterial branches, or continue before splitting into the branches. In 7.5% of the investigated cases the trunk divided into 3 dorsal branches on the dorsum of the foot.

The alternative arrangement found in the distribution of the DFN was the formation of loops. The loops found in the DFN are formed when the distal branches of the DFN unite more distally and then branches again. For correct diagnosis of recurrent anterolateral foot pain after an ankle sprain due to nerve compression, the anatomical nerve pathways need to be known. For this reason, the different arrangements need to be investigated to ensure adequate and correct diagnosis.

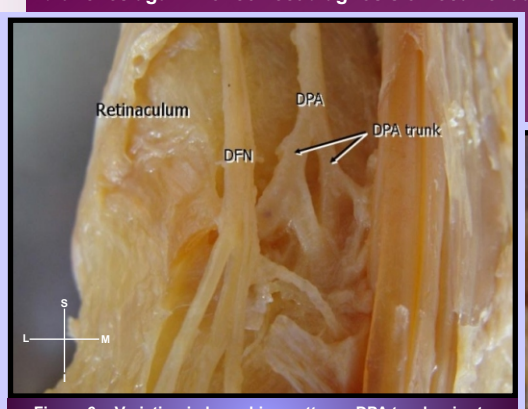

Figure 6a: Variation in branching pattern: DPA trunk prior to branching

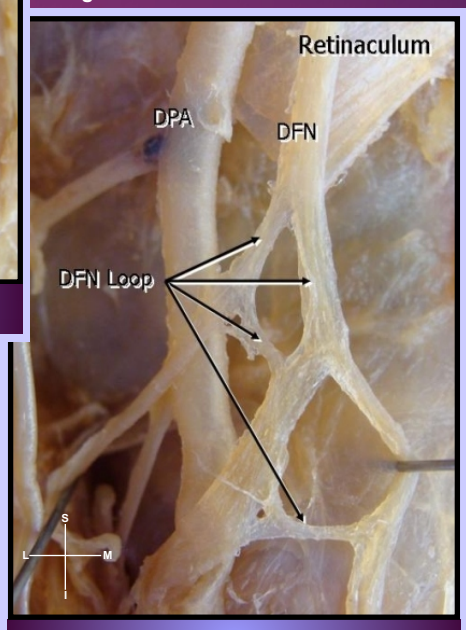

Figure 6b: Variation in branching pattern: DFN loop

In a comparison to the studies done by Ranade *et al* (2008)1 and Ikiz *et al* (2007)[5], there are various different relations between the distribution of the DPA and DFN.[1, 5] Ranade *et al* investigated whether the DFN branches lateral, medial or over the DPA.[1] Ikiz *et al* studied the DPA and DFN relationship in the anterior tarsal tunnel.[5] Due to the different approaches of the compared studies, no direct comparison can be made. However, in this cadaver study the relationship between the DPA and DFN was more thoroughly investigated and noted. This will aid in the understanding of the neurovascular supply of the ankle and the dorsum of the foot.

Conclusion

We have found that the term "bifurcation" cannot be used to describe the termination of the DPA as the diameters of the branches are not similar.
In addition, both the DPA and DFN often give rise to branches deep to the IER (57.5% and 55.0% respectively) and the distance between the DPA and DFN divisions may vary significantly although the mean was determined as 7.79mm ± 2.8. Awareness of these variations may prevent neurovascular injuries during vascular and reconstructive surgery and decrease postoperative complications.

References

1. Ranade, AV, Rajanigandha V, Rai R, Ebenezer DA. Relationship between the deep peroneal nerve and dorsalis pedis artery in the foot: a cadaveric study. Clinical Anatomy 2008; 21:705 712.
2. Chattar-Cora D, Pederson WC. Experience with the extensor digitorum brevis muscle flap for foot and ankle reconstruction. Annals of plastic surgery. 2006; 57:289 294.
3. Eo S, Kim Y, Kim JY, Oh S. The versatility of the dorsalis pedis compound free flap in hand reconstruction. Annals of Plastic Surgery. 2008; 61(2):157 163.
4. Moore LK, Dalley AF. Clinically Orientated Anatomy 5th edition. Lippincott Williams and Wilkins. 2006: 587; 642; 667-671.
5. Aktan Ikiz ZA, Ucerler H & Uygur M. The clinical importance of the relationship between the deep peroneal nerve and the dorsalis pedis artery on the dorsum of the foot. Plastic & reconstructive surgery. 2007; 120(3):690 696.
6. Pomposelli F, Maecaccio E, Gibbons G, Campbell D, Freeman D, Burgess A, Miller A, LoGerfo F. Dorsalis pedis arterial bypass: Durable limb salvage for foot ischemia in patients with diabetes mellitus. Journal of Vascular Surgery 21(3):375 984.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Health Sciences