ORIGINAL ARTICLE

Anatomy Journal of Africa. 2019. Vol 8 (1):1444 - 1451

THE ANATOMICAL PATTERN OF THE DORSALIS PEDIS ARTERY AMONG BLACK KENYANS

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ABSTRACT

Knowledge of the anatomical pattern of dorsalis pedis artery is important during evaluation of peripheral circulation, peripheral vascular disease, microvascular flap, ankle and foot surgery. Reports from other populations on the pattern show wide disparity suggesting ethnic and geographical differences. Data from black African populations is scanty. This study therefore examined the anatomical pattern of dorsalis pedis artery among adult black Kenyans. The cadaveric dissection study on 30 formalin fixed specimens evaluated the origin, position, course and branching pattern of the dorsalis pedis artery. The data were analysed using SPSS for means, frequency and standard deviation. Student t – test was used to determine side differences at 95% confidence interval where P – Value of <5% was taken as statistically significant. The artery was consistently present, as a continuation of the anterior tibial artery. It ran 4.6 mm ± 2.1 mm from the medial malleolus, and about 2.5 ± 0.3mm from the medial border of the base of the first metatarsal bone. The mean was 4.76 mm on the right, and 4.56 mm on the left. The difference was statistically significant (P<0.05). Three branching patterns were observed. The conventional pattern was observed in only 47% of cases. The extensor hallucis longus tendon most frequently crossed the artery above the ankle joint. There were no cases of crossing below the ankle. These observations reveal that the dorsalis pedis artery is consistently present, high, relatively medialised, and displays an atypical branching pattern. Due care should be taken during surgery. Preoperative ultrasound evaluation is recommended.

Keywords: Dorsalis pedis, origin, branching course, ankle joint

INTRODUCTION

Dorsalis pedis artery (DPA), the principal blood supply to the dorsum of the foot, is usually a continuation of the anterior tibial artery (ATA). It is located a point 1/3 from the medial malleolus at the talocrural joint just distal to the inferior extensor retinaculum. Initially, it is located lateral to the extensor hallucis longus (EHL) tendon. It then courses distally along the medial side of the dorsum of the foot where the EHL tendon crosses it. The artery runs distally between the 2 heads of the first dorsal interosseous muscle, gives off the arcuate artery, lateral tarsal and medial tarsal arteries and terminates by giving the deep plantar and the first dorsal metatarsal arteries (Standring, 2008; Sinnatamby, 2011). The artery displays variation in origin, position, course and branching pattern (Ranade et al., 2008; Vijayalakshni et al., 2011). Knowledge of the anatomical pattern, including variations, of DPA is important for the following reasons: First, it serves as an important landmark on the dorsum of the foot. DPA pulse is used for the assessment of distal peripheral circulation (Mowlavi et al., 2002; Vijayalakshmi et al., 2011; Kulkarni and Ramesh, 2012); Second, it may be a site of arterial diseases like atherosclerosis and aneurysm (Kato et al., 2004; Al – Omran, 2012); Third, it influences microvascular surgery where the DPA and its branches are used as a stem for myocutaneous flap in reconstructive as well as plastic surgery-myocutaneous flaps of DPA are also an integral component in reconstructive surgeries of the hand, eye socket and pharyngocutaneous fistulae (Kulkarni and Ramesh, 2012; Mamatha et al., 2014); Four, it

Submitted 26th July 2018. Published online 14th February 2019. To cite: Amuti T, Rwegasira E, Ouko I, Ongeti K, Ogeng'o J. 2019. Anatomical pattern of the dorsalis pedis artery among black Kenyans. Anatomy Journal of Africa. 8: 1444 – 1451.

plays an important role in microvascular surgery of the foot during replantations, reconstructions and repair (Vijayalakshni et al., 2011; Chepte and Ambiye, 2018); five, it is valuable in reducing the risk of pseudoaneurysm formation during ankle arthroscopy and reducing inadvertent injury during surgical management of foot ulcers (Yamada et al., 1993; Awari and Vatsalaswamy, 2016; Parkish et al., 2017); six, it is invaluable to surgeons during preoperative vascular mapping of the foot (Chow et al., 2005); seven, it increases the success rate of podiatric surgery and is important for angiographers, vascular and reconstructive surgeons (Aithal et al., 2015; Luckajh et al., 2018).

Frequency of variations of DPA varies between populations (Luckrajh et al., 2018). Recently, there have been several reports on South African population (Prigge and Briers, 2016; Ntuli et al., 2018; Luckrajh et al., 2018), describing mainly the origin and branching pattern. These studies underpin the ethnic and possibly geographical variation but do not address position and course in detail. Data for the Kenyan population are, however, lacking all together. This study, therefore, determined the anatomical pattern of the DPA, with special reference to variations.

MATERIALS AND METHODS

This was a descriptive cross-sectional study of 30 formalin fixed cadaveric feet of adult black Kenyans. It was performed at the Department of Human Anatomy, University of Nairobi. To locate the DPA, the skin on the dorsum of the foot was reflected from the middle 1/3 of the leg to the tip of the toes. Subsequently, the fascia cruris and fascia pedis were reflected to expose the underlying muscular and vascular structures. The extensor group of muscles of the leg were then exposed and reflected to expose the anterior tibial artery. This artery was followed until the point equilateral to the ankle joint where it became the DPA. Exposure and reflection of the tendons of the extensor group of leg muscles further revealed the course of the DPA on the dorsum of the foot. The DPA was identified as that artery which coursed distally along the medial side of the dorsum of the foot from deep to the EHL, between the 2 heads of the first dorsal interosseous muscle, and terminated by giving the deep plantar artery and the first dorsal metatarsal artery.

Four variables were studied – origin, position, course and branching pattern. The origin of the DPA as either the continuation of the ATA or peroneal artery was noted. Its point of origin from the medial malleolus was measured using Vernier calipers. Its course on the dorsum of the foot was studied in relation to the medial malleolus, base of 1st metataisal, medial edge of the base of the navicular bone and tendons of EHL, EDL. The branching pattern was examined and recorded. Data was recorded and images were taken using a high-resolution digital camera (Carl Zeiss, 12.1 megapixels).

The data was coded into SPSS from where means for the different data was calculated. Side variations were also analyzed using paired t-test. A p-value of ≤ 0.05 was considered significant at 95% confidence interval. Data were presented using tables and macrographs.

RESULTS

The DPA was present in all 30 dissected limbs.

Origin and position

In all the limbs, the vessel originated as the continuation of the ATA. When measured from

the medial border of the medial malleolus, the right DPA has an average distance of 4.76 mm (4.46-5.07) from the medial border of the medial malleolus, while the left 4.56mm (4.25-4.87) mm with regard to the distance of the DPA from the medial border of the base the first metatarsal bone, the right DPA was 2.43 mm (2.24-2.63) from the edge while the left was at 2.35 mm (2.10-2.60) mm [Table 1].

Course

In relation to EHL, the right EHL tendon was observed to cross the right DPA above the ankle in 60% of the cases and at the ankle in 40%, whereas on the left side, the EHL crossed the DPA above the ankle in 54% of the cases and at the ankle in 46%. No crossings below the ankle joint were noted (Table 2).

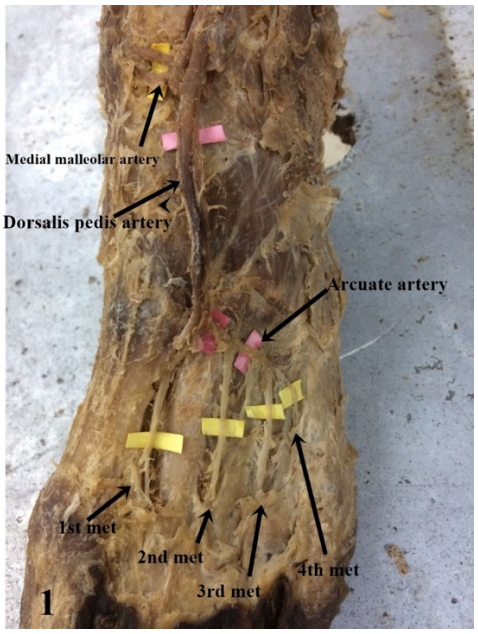


Figure 1: Image showing the first type branching pattern of the dorsalis pedis artery. Note the DPA giving the AA artery (which gives the 2nd to 4th DMA) while the DPA continues as the first DMA.

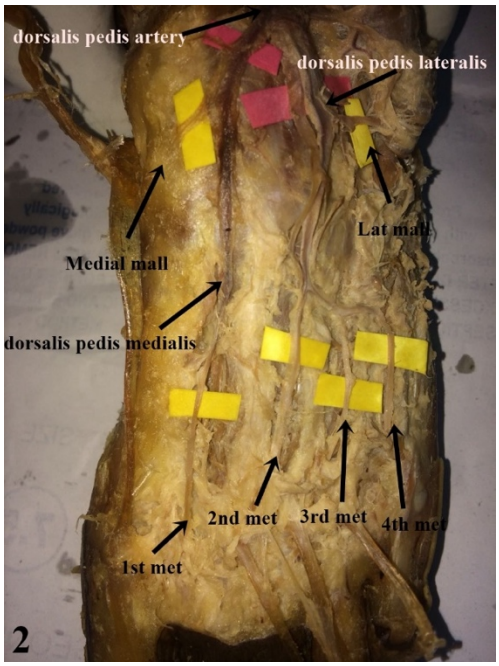


Figure 2: Image showing the second type branching pattern of the dorsalis pedis artery. Note the the DPA dividing to give a lateral DPA and a medial DPA. The lateral DPA gives the 2nd to 4th DMA while the medial DPA continues as the first DMA.

Table 1: Table showing the morphometric variations of the DPA

Variable	Side	Range (mm)	Mean (mm)	Statistical Significance
Position of the Dorsalis Pedis artery as measured from the medial malleolus	Right	4.46 – 5.07	4.76	0.000*
	Left	4.25 – 4.87	4.56	
Position of the Dorsalis Pedis artery as measured from the medial border of the base of the first metatarsal bone	Right	2.24 – 2.63	2.43	0.000*
	Left	2.10 – 2.60	2.35	
	Left	2.77 – 4.30	3.54	

Table 2: Topographic Variations of dorsalis pedis artery

Branching of the DPA	Right	Type 1	33%
		Type 2	20%
		Type 3	47%
	Left	Type 1	47%
		Type 2	13%
		Type 3	40%
Level of crossing of Extensor Hallucis Longus tendon	Right	Above ankle	60%
		At ankle	40%
	Left	Above ankle	54%
		At ankle	46%

Branching Pattern

The following three branching patterns were observed: In the first, the DPA gave the AA artery and continued as the first DMA. In the second, the DPA divided to give a lateral DPA and a medial DPA. In the third pattern, the DPA gave the 2nd DMA as a single branch and the lateral tarsal artery then continued off as the 1st DMA (Table 2).

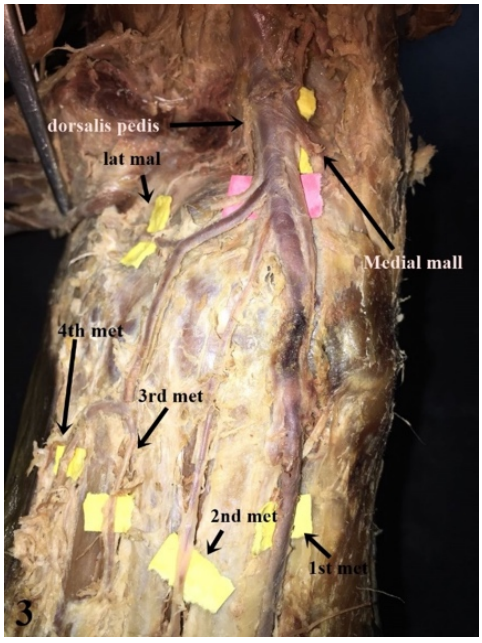


Figure 3: Image showing the third type branching pattern of the dorsalis pedis artery. Note the the DPA gives out the 2nd DMA as a single branch and the lateral tarsal artery (which gives out the 3rd and 4th DMA). It then continues off as the 1st DMA.

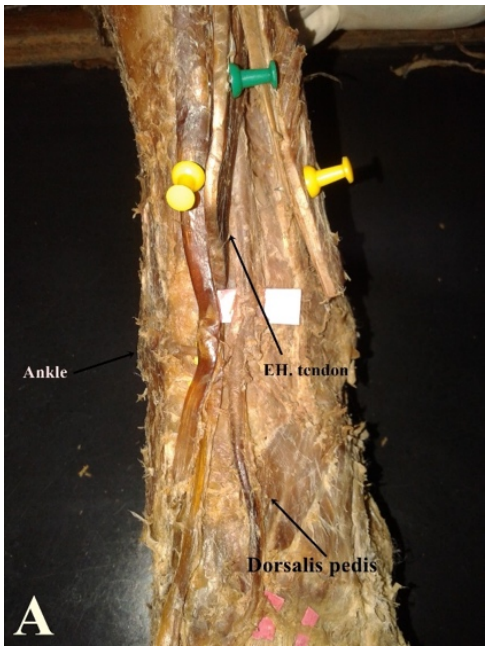


Figure A: Image showing the extensor halluces longus tendon above the ankle.

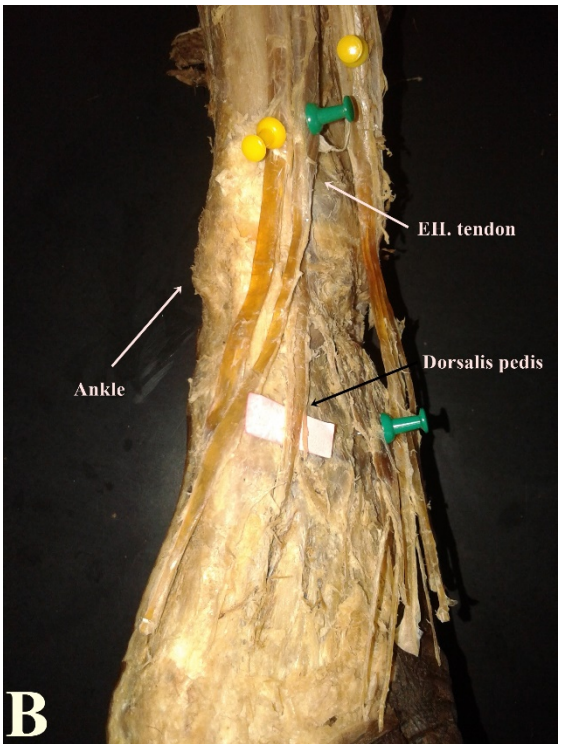
1. 

Figure B: Image showing the extensor halluces longus tendon crossing at the ankle.

DISCUSSION

The DPA was found in all the 30 feet dissected. These findings are at variance with those of the Indian (Vijayalakshmi et al., 2011) and American (Yamada et a1.,1993) populations where the vessel was absent in 2% and 6% respectively. In the South African population, the artery was absent in upto 6% of cases (Luckrajh et a., 2018; Ntuli et al., 2018). Variations of the DPA could be attributed to combinations of persistent primitive arterial segments, abnormal fusions, segmental hypoplasia or absence during embryology (Atanasova et al., 2011). The consistent presence in the Kenyan population implies that failure to palpate DPA pulse is highly suggestive of peripheral vascular disease.

Origin

In the current study, DPA was consistently a continuation of the ATA. This is at variance with data from India showed that the DPA arises as the continuation of the peroneal artery in 8% of cases, (Vijayalakshni et al., 2011). This was similar to data from USA, where the DPA arose as continuation of the peroneal artery in 6.7% of the population (Yamada et al., 1993). Several other studies have reported a significant proportion of DPA originating from peroneal artery (Aithal et al., 2015; Luckrajh et al., 2018). This suggests that in the Kenyan population that disease of ATA will invariably affect the foot, whereas in the others, a significant proportion will be spared.

Position and Course

The point of origin of the DPA as measured from the medial malleolus was found to be medially deviated. When compared to the distance from the medial to the lateral malleolus, it was found at distance 2/5 from the medial malleolus. This finding varies from standard text book descriptions where the vessel is located in the midline at the ankle joint (Standring, 2008), and from a study done in India which showed that the vessel can have a lateral deviation from its normal midline position (Vijayalakshni et al., 2011). With regard, to its course on the dorsum

of the foot, a study done in the Japanese population showed that the vessel can have a lateral deviation and thus travel on the lateral end of the navicular as compared to the normal course, superior to the navicular bone (Hamada et al., 1994). Variation on the point of origin of the DPA as measured from the medial malleolus and course on the dorsum of the foot may influence the taking of the DPA pulse (Vijayalakshni et al., 2011). The DPA pulse is usually palpated lateral to the extensor hallucis longus tendon or medial to the extensor digitorum longus tendon on the dorsal surface of the foot superior to the navicular bone (Mowlavi et al., 2002) In cases of variations like those observed in the current study, however, this may prove difficult.

Relationship with EHL tendon

The EHL tendon crossed DPA proximal to the ankle joint. There were no crossings below the ankle joint recorded. This is different from a USA population, where the DPA crossed above the ankle in 42%, at the ankle in 53%, and below the ankle in 3% (Yamada et al., 1993). The point where the EHL tendon crosses the ankle is of surgical importance since the EHL may compress the grafts done on the DPA and disrupt the anastomosis if the grafting is done where the tendon crosses the vessel (Yamada et al., 1993). Therefore, in the Kenyan population since the EHL crosses the vessel either above or at the ankle joint, grafting of the DPA may be suitable if done below the ankle joint.

Branching Pattern

In the current study, 3 types of DPA branching were observed. This is different from a study on the American population (Yamada et al., 1993) where only two patterns were identified. Additionally, of the two patterns that were similar in our setting, the first pattern where the vessel did not branch has a lower appearance in our setting at 40% compared to the 76% in the America study. However, the second pattern where the vessel branched into two only appeared in 16% of the cases in our setting similar to that of America.

Regarding its branching pattern, upto 10 patterns have been described in other populations (Luckrajh et al., 2018; Chepte and Ambiye, 2018). For example, data from India showed that in 16% of the cases, the vessel branched into two; the lateral dorsalis pedis and the medial dorsalis pedis which then supplied the dorsum of the foot. In the remaining 84%, the vessel maintained its normal anatomy and did not branch into two (Vijayalakshmi et al., 2011). The proportion of the conventional branching is highly variable [Table 3].

Table 3: Frequency of conventional branching of DPA

Reference	Population	Proportion of DPA with conventional branching pattern (%)
Rajeshwari et al., 2013	Indian	55
Kumari and Bharti, 2016	Indian	73
Luckrajh et al., 2018	South African	42.5
Chepte and Ambiye, 2018	Indian	73.3
Ntuli et al., 2018	South African	36.4
Gupta et al., 2018	Indian	91
Current Study, 2018	Kenyan	47

These findings reveal wide variations between and within populations. Variations of the DPA branches may influence microvascular surgery. The DPA and its branches are used as a stem for myocutaneous flap in reconstructive as well as plastic surgeries (Vijayalakshmi et al., 2011).

Therefore, anatomical variations in the origin, course and branching of DPA can affect the success of these surgeries in the Kenyan population.

In conclusion, these observations reveal that the dorsalis pedis artery is consistently present, high, relatively medialised, and displays an atypical branching pattern. Due care should be taken during surgery. Preoperative ultrasound evaluation is recommended.

ACKNOWLEDGEMENTS: We are grateful to Margaret Irungu and Acleus Murunga for technical support, and Antonina Odock for typing the manuscript.

CONFLICT OF INTEREST: There is no conflict of interest in the study

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