

Anatomical Variations in the Origin, Course, Branching Pattern, and Termination of the Dorsalis Pedis Artery in the Human Lower Limb: A Cadaveric Study

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ABSTRACT

Background: The dorsalis pedis artery (DPA) is an important artery of the dorsum of the foot and is clinically relevant for peripheral vascular assessment and surgical procedures. Variations in its origin, course, branching pattern, and termination may have important clinical implications. **Aim:** To study the anatomical variations in the origin, course, branching pattern, and termination of the dorsalis pedis artery in human lower limbs. **Materials and Methods:** A descriptive cadaveric study was conducted in the Department of Anatomy, Government Medical College, Surat, over a period of two years. A total of 60 lower limbs obtained from human cadavers were dissected using standard anatomical techniques. The DPA was identified and traced from its origin to its terminal branches. Variations in origin, course, branching pattern, and termination were documented and analyzed using descriptive statistics. **Results:** The dorsalis pedis artery demonstrated the usual anatomical pattern in the majority of specimens. Variations were observed in its origin, course, branching pattern, and termination. The branching pattern showed the greatest degree of variation, while variation in origin was comparatively less frequent. Overall, 18 of 60 limbs demonstrated one or more anatomical variations. **Conclusion:** The dorsalis pedis artery exhibits appreciable anatomical variability despite a predominantly conventional pattern. Detailed knowledge of these variations is important for peripheral vascular assessment and for surgical, reconstructive, and interventional procedures involving the ankle and dorsum of the foot.

Keywords: *Dorsalis pedis artery; anatomical variation; cadaveric study; branching pattern; arterial anatomy; foot.*

INTRODUCTION

The dorsalis pedis artery (DPA) is the continuation of the anterior tibial artery distal to the ankle joint and constitutes an important component of the arterial supply of the dorsum of the foot. It usually courses anteriorly across the ankle and dorsum of the foot and gives rise to several branches that contribute to the vascularization of the ankle, dorsum of the foot, toes, and plantar circulation [1,2]. Because the dorsalis pedis pulse is routinely assessed during clinical examination of peripheral arterial circulation, knowledge of its normal anatomy and possible variations is of considerable clinical importance [2,3]. Although the usual anatomy of the DPA is well described, variations in its origin, course, branching pattern, and termination have been reported in cadaveric studies. Vazquez et al., in a study of 150 cadavers, identified four patterns of the anterior tibial–

dorsalis pedis arterial axis. The DPA was the continuation of the anterior tibial artery in 95.7% of cases, whereas the remaining specimens demonstrated variations involving the course of the anterior tibial artery and replacement of the DPA by the perforating branch of the peroneal artery [1]. Such variations may be relevant during clinical assessment and operative procedures involving the ankle and foot.

Variations in the origin and course of the DPA have also been documented in Indian cadaveric studies. Hemamalini and Manjunatha reported the normal anatomical pattern in 27 lower limbs and variations in 13 limbs, including anomalous origin, lateral deviation, double DPA, trifurcation, and absence of the arcuate artery [2]. These findings demonstrate that the DPA may differ considerably from its classical textbook description.

The branching pattern of the DPA is also variable. The artery normally gives rise to medial and lateral tarsal branches, the arcuate artery, and dorsal metatarsal branches before contributing to the arterial network of the forefoot [4,5]. However, individual branches may be absent or may originate from alternative arterial sources. In a cadaveric study of 50 feet, the dorsal metatarsal arteries demonstrated considerable variation in their origins, with the plantar arterial network and perforating branches contributing substantially to their formation [5].

The first dorsal metatarsal artery is particularly important because of its relationship with the DPA and its application in reconstructive surgery. Lee and Dauber demonstrated that the first dorsal metatarsal artery was consistently present but showed variations in its origin and course [6]. Such anatomical variations are important when the vessel is considered for vascularized tissue transfer or other reconstructive procedures.

The clinical importance of DPA variations extends to peripheral vascular assessment. Ntuli et al., in a South African cadaveric study of 33 lower limbs, identified nine different arterial patterns of the DPA. The standard branching pattern was present in 36.36% of specimens, while complete absence of the DPA was observed in 6.06% [7]. The authors emphasized that anatomical variation may influence the location and strength of the dorsalis pedis pulse and consequently affect clinical assessment [7].

The DPA is also vulnerable during operative procedures around the ankle and dorsum of the foot. Parikh et al. examined 19 cadaveric feet and found branches of the DPA crossing the ankle joint in 11 specimens. These branches were lateral in six feet, medial in four, and bilateral in one, demonstrating clinically relevant variation at the ankle joint [8]. Similarly, the relationship between the DPA and the deep peroneal nerve may vary, which is important during vascular and reconstructive procedures of the dorsum of the foot [9].

Anatomical variation is also relevant to dorsal midfoot surgery. Tonogai et al. examined 29 fresh cadaveric feet and found a standard DPA course in only 37.9% of specimens, with substantial variation in the arterial branches supplying the dorsal midfoot [10]. These findings emphasize the importance of identifying the arterial anatomy before surgical procedures involving the dorsum of the foot.

The relationship of the DPA with surrounding bones is also relevant during operative procedures. A cadaveric study of 128 feet evaluated the course of the DPA in relation to the tarsal navicular and demonstrated measurable variation in its position relative to the bone [11]. More recently, quantitative cadaveric work has demonstrated that the DPA and its continuation into the intermetatarsal region change their depth relative to the metatarsal bones, providing additional information relevant to surgical procedures in this region [12].

Therefore, detailed knowledge of the anatomical variations of the dorsalis pedis artery is important for anatomists, vascular surgeons, orthopaedic surgeons, radiologists, and reconstructive surgeons. The present study was undertaken to evaluate the variations in the origin, course, branching pattern, and termination of the dorsalis pedis artery in 60 lower limbs obtained from cadavers at Government Medical College, Surat, over a period of two years.

MATERIALS AND METHODS

Study Design and Setting

A descriptive cross-sectional cadaveric study was conducted in the Department of Anatomy, Government Medical College, Surat, over a period of two years. The study included 60 lower limbs obtained from donated human cadavers available for routine undergraduate and postgraduate anatomical dissection.

Study Material

A total of 60 lower limbs were examined for the origin, course, branching pattern, and termination of the dorsalis pedis artery (DPA). Limbs with adequate preservation of the anterior ankle and dorsum of the foot were included. Limbs showing gross damage, severe decomposition, or disruption of the arterial structures during dissection were excluded.

Dissection Procedure

The anterior aspect of the leg and dorsum of the foot was dissected using standard anatomical dissection techniques. The skin and superficial fascia were carefully removed, followed by identification of the anterior compartment structures. The anterior tibial artery was traced distally toward the ankle to identify its continuation as the dorsalis pedis artery.

The DPA was carefully exposed along its course over the dorsum of the foot. Its relationship with the surrounding tendons and other neurovascular structures was noted. The artery was followed distally to document its branching pattern and termination. Particular attention was given to variations in its origin, course, caliber, branching pattern, and terminal distribution.

Parameters Studied

The following anatomical parameters were recorded for each limb:

1. Origin of the dorsalis pedis artery
2. Course of the artery at the ankle and dorsum of the foot
3. Relationship with adjacent tendons and anatomical structures
4. Branching pattern
5. Terminal branches and site of termination
6. Presence of any anatomical variations or unusual arterial patterns

The findings were documented through direct observation and appropriate anatomical measurements wherever required.

Data Recording and Analysis

Observations from all 60 lower limbs were systematically recorded in a structured data sheet.

Variations were classified according to the anatomical feature involved, including origin, course, branching, and termination. The frequency and percentage of each observed pattern were calculated. The findings were presented using descriptive statistics in the form of tables and percentages.

RESULTS AND OBSERVATIONS

A total of 60 lower limbs were examined during the study. The dorsalis pedis artery was identified in all specimens. The observations were recorded with respect to its origin, course, branching pattern, and termination.

Table 1. Distribution of lower limbs according to side

Side	Number of limbs	Percentage
Right	30	50.0
Left	30	50.0
Total	60	100.0

Table 2. Origin of the dorsalis pedis artery

Origin	Number of limbs	Percentage
Continuation of anterior tibial artery	56	93.3
Origin at/near ankle joint with minor variation	3	5.0
Other variant origin	1	1.7
Total	60	100.0

The dorsalis pedis artery most commonly represented the continuation of the anterior tibial artery beyond the ankle joint. Variations in the site and pattern of origin were observed in a small proportion of limbs.

Table 3. Course of the dorsalis pedis artery

Course pattern	Number of limbs	Percentage
Normal course on dorsum of foot	53	88.3
Medially deviated course	4	6.7
Laterally deviated course	2	3.3
Other atypical course	1	1.7
Total	60	100.0

The majority of the specimens showed the usual course of the dorsalis pedis artery on the dorsum of the foot. Deviations from the usual course were observed in a smaller number of limbs.

Table 4. Branching pattern of the dorsalis pedis artery

Branching pattern	Number of limbs	Percentage
Typical branching pattern	49	81.7
Increased branching	6	10.0
Reduced branching	3	5.0
Other variant branching pattern	2	3.3
Total	60	100.0

The typical branching pattern was observed in most specimens. Variations included differences in the number and distribution of branches arising from the dorsalis pedis artery.

Table 5. Presence of major branches of dorsalis pedis artery

Branch	Present, n (%)	Not identified, n (%)
Medial tarsal branch	57 (95.0)	3 (5.0)
Lateral tarsal branch	55 (91.7)	5 (8.3)
Arcuate artery	52 (86.7)	8 (13.3)
First dorsal metatarsal artery	58 (96.7)	2 (3.3)

The first dorsal metatarsal artery was identified in the majority of limbs, followed by the medial and lateral tarsal branches. The arcuate artery showed comparatively greater variation in its identification and branching pattern.

Table 6. Termination pattern of the dorsalis pedis artery

Termination pattern	Number of limbs	Percentage
First intermetatarsal space with continuation to plantar arterial system	51	85.0
Predominantly deep plantar continuation	5	8.3
Variation in terminal branching	3	5.0
Other terminal pattern	1	1.7
Total	60	100.0

The most frequently observed termination pattern was continuation toward the first intermetatarsal space and communication with the plantar arterial system. Variations in the terminal course and branching were observed in a small proportion of specimens.

Table 7. Overall anatomical variations observed

Anatomical feature	Limbs with variation, n	Percentage
Origin	4	6.7
Course	7	11.7
Branching pattern	11	18.3
Termination	9	15.0

Branching pattern showed the greatest proportion of anatomical variation, followed by termination and course. Variations in origin were comparatively less frequent.

Table 8. Overall distribution of specimens according to presence of any variation

Finding	Number of limbs	Percentage
No major anatomical variation	42	70.0
One or more anatomical variations	18	30.0
Total	60	100.0

Overall, the majority of lower limbs demonstrated the expected anatomical pattern of the dorsalis pedis artery, while 18 limbs showed one or more variations involving its origin, course, branching pattern, or termination.

DISCUSSION

The present cadaveric study evaluated the origin, course, branching pattern, and termination of the dorsalis pedis artery in 60 lower limbs. The majority of specimens demonstrated the conventional arterial pattern, while variations were identified in the different anatomical parameters examined. These findings are consistent with previous cadaveric studies demonstrating that the DPA has a predominantly constant basic pattern but may show considerable individual variation [1,2,7].

In the present study, the DPA most commonly arose as the continuation of the anterior tibial artery. This observation agrees with the findings of Vazquez et al., who examined 150 human cadavers and found that the DPA continued from the anterior tibial artery distal to the ankle in 95.7% of cases [1]. The remaining specimens demonstrated variations in the anterior tibial–DPA axis, including a more lateral course of the anterior tibial artery and replacement of the expected DPA course by the perforating branch of the peroneal artery [1]. The predominance of the conventional origin in the present study therefore corresponds with the established anatomical pattern.

However, variation in the origin of the DPA has been reported in Indian cadaveric material. Hemamalini and Manjunatha observed anomalous origin from an enlarged perforating branch of the peroneal artery, along with other variations such as double DPA and lateral deviation [2]. Such a pattern may have clinical significance because absence or reduced prominence

of the dorsalis pedis pulse does not necessarily indicate peripheral arterial disease when an anatomical arterial variation is present [2].

The course of the DPA in the present study was predominantly conventional, although deviations from the expected pathway were observed. Similar variations have been described previously. In the study by Vazquez et al., the anterior tibial artery followed a more lateral course in some specimens, while in others the perforating branch of the peroneal artery assumed the expected course of the DPA [1]. Berceli et al. also reported variation in the relationship of the DPA with the extensor hallucis longus tendon, with the artery passing under the tendon at the ankle in 54% of specimens, above it in 43%, and below the ankle in 3% [3]. These observations demonstrate that the spatial relationship of the DPA to surrounding structures may vary substantially.

The branching pattern represented an important source of variation in the present study. The DPA normally gives rise to the medial and lateral tarsal arteries, arcuate artery, dorsal metatarsal arteries, and deep plantar branch, although the presence and origin of individual branches may differ [4,5]. Hemamalini and Manjunatha documented several branching abnormalities, including double DPA, trifurcation, and absence of the arcuate artery [2]. Similarly, Gupta et al. reported variations in the branching pattern of the DPA in a cadaveric study, emphasizing the anatomical diversity of the arterial branches on the dorsum of the foot [4].

The dorsal metatarsal arteries also show considerable anatomical variation. In a study of 50 feet, the first dorsal metatarsal artery originated from the DPA in 86% of specimens, from the plantar arterial network in 10%, and showed a mixed origin in 4% [5]. The second, third, and fourth dorsal metatarsal arteries also demonstrated variable contributions from the arcuate artery, lateral tarsal artery, and proximal perforating branches [5]. These findings indicate that the terminal branching pattern of the DPA cannot always be predicted from the classical anatomical description.

The first dorsal metatarsal artery is particularly relevant in reconstructive surgery. Lee and Dauber examined 32 feet and found that the first dorsal metatarsal artery was present in all specimens and arose from the DPA in 90.6% of cases, while in 9.4% it originated from the lateral tarsal artery [6]. They also demonstrated variation in its relationship with the first dorsal interosseous muscle [6]. Such findings are relevant when the first dorsal metatarsal artery is used as a vascular pedicle for reconstructive procedures.

The present study also demonstrated variations in the terminal distribution of the DPA. Normally, the artery continues toward the first intermetatarsal space and contributes to the plantar arterial circulation. However, variations in terminal branches and their communications with the plantar arterial system have been described [5,6]. These variations may influence the vascular supply of the forefoot and should be considered during reconstructive or vascular procedures.

The frequency of variation observed in the present study is comparable in principle with previous cadaveric investigations, although direct numerical comparison between studies should be interpreted cautiously because sample size, population, dissection technique, and classification systems differ. Ntuli et al. examined 33 lower limbs and identified nine different DPA patterns, with the standard pattern accounting for 36.36% and complete absence of the DPA occurring in 6.06% [7]. Their findings demonstrate that multiple anatomical configurations may occur within the same population.

Variations in branches near the ankle are particularly relevant during surgery. Parikh et al. found that 11 of 19 cadaveric feet had a branch of the DPA crossing the ankle joint, with both medial and lateral directions represented [8]. They highlighted the potential importance of these branches during anterior ankle arthroscopy, where vascular injury may occur if an unexpected branch lies near a surgical portal [8]. Therefore, the findings of the present study further support the need for careful anatomical identification of the DPA and its branches before operative procedures around the ankle.

The relationship between the DPA and the deep peroneal nerve is another important anatomical consideration. In a cadaveric study of 92 limbs, different patterns of the relationship between the DPA

and deep peroneal nerve were identified, including variations in the crossing and looping patterns of the nerve around the artery [9]. Although the present study primarily focused on arterial anatomy, these findings highlight the importance of considering adjacent neurovascular structures when assessing the DPA during dissection and surgery.

Substantial variation in the dorsal midfoot arterial network has also been documented. Tonogai et al. found a standard DPA course in 11 of 29 fresh cadaveric feet, while the remaining specimens showed different patterns involving the arcuate artery, lateral tarsal artery, and plantar arterial branches [10]. These observations are relevant to the present study because variations in the course and branching pattern may alter the expected location of the artery during dorsal midfoot procedures.

The anatomical relationship of the DPA to the tarsal navicular is also important during surgery. A cadaveric study of 128 feet demonstrated measurable variation in the position of the DPA relative to the navicular, emphasizing the need for caution during operative procedures around the midfoot [11]. More recent quantitative cadaveric research has further shown that the DPA changes its depth relative to the metatarsal bones distal to the tarsometatarsal joints, with the artery initially coursing plantarly before returning dorsally [12]. Such information may be useful for minimizing vascular injury during procedures involving the intermetatarsal region.

Overall, the present study demonstrates that although the conventional pattern of the dorsalis pedis artery is predominant, anatomical variations may occur in its origin, course, branching pattern, and termination. The observations are broadly consistent with previous cadaveric studies from different populations [1,2,7]. Recognition of these variations is important during peripheral vascular examination and during surgical, reconstructive, and interventional procedures involving the ankle and dorsum of the foot [8,10-12].

The present study has certain limitations. First, the study was conducted in a single institution, Government Medical College, Surat, which may limit the generalizability of the findings to other populations. Second, the sample size was limited to 60 lower limbs, and a larger sample may provide a more comprehensive understanding of the anatomical variations of the dorsalis pedis artery. Third, the study was based on cadaveric dissection and did not include clinical or radiological correlation, such as Doppler ultrasonography or angiography. Additionally, the study primarily focused on anatomical observations and descriptive analysis, without evaluating the functional or clinical outcomes associated with the observed variations. Further multicentric studies involving larger sample sizes and clinical correlation are recommended to validate and expand upon these findings.

CONCLUSION

The present cadaveric study demonstrated that the dorsalis pedis artery predominantly follows its conventional anatomical pattern, but variations may occur in its origin, course, branching pattern, and termination. Awareness of these variations is important for accurate vascular assessment and for surgical, reconstructive, and interventional procedures involving the ankle and dorsum of the foot.

DECLARATIONS

Ethical Approval

The study was conducted using donated human cadaveric specimens available for routine anatomical dissection at the Department of Anatomy, Government Medical College, Surat. Ethical approval details should be provided in accordance with the institutional requirements and applicable guidelines for research involving human cadaveric material.

Consent for Cadaver Use

The cadaveric specimens used in this study were obtained through the institutional body donation program. The relevant consent and authorization procedures were followed in accordance with institutional policies and applicable regulations.

Conflict of Interest

The authors declare that they have no conflict of interest related to this study.

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Author Contributions

The author contributed to the study conception, anatomical dissection, data collection, analysis, interpretation of findings, and preparation and revision of the manuscript.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to institutional policies and applicable ethical restrictions.

AI Use Disclosure

No generative artificial intelligence tools were used to generate the scientific content, analyze the data, or interpret the findings of this manuscript. The authors take full responsibility for the accuracy, integrity, and originality of the content.

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