Section: Anatomy

Original Research

# DORSALIS PEDIS ARTERY VARIATIONS- A META-ANALYSIS STUDY

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Corresponding Author:
**Dr. Srikanth K,**
Email: drsrikanth2587@gmail.com
ORCID: 0000-0002-2854-825X

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**Nirmal Kumar K[1], Kalyana Panchakshari P[2], Srikanth K[3]**

[1]Assistant Professor, Department of Anatomy, Mahavir Institute of Medical Sciences, Vikarabad, India
[2]Assistant Professor, Department of Anatomy, Mahavir Institute of Medical Sciences, Vikarabad, India.
[3]Assistant Professor, Department of Vascular Surgery, Tirunelveli Medical College, Tirunelveli, Tamil Nadu, India.

## Abstract

**Background:** Dorsalis pedis artery (DPA) is the major source of vascularisation to the structures in the foot. Empirical evidence significantly reported the DPA variations. The aim of this study was to do a meta-analysis on reported DPA variations. **Materials and Methods:** A thorough search of major electronic databases like Medline, PubMed central, Scopus, Embase, Web of science and ScienceDirect was done to collect the data related to DPA variations. In addition, references of DPA variations studies were searched. All data related to DPA variations were extracted and integrated into a meta-analysis. A total of 25 studies (n=1291 lower limbs) were included. **Result:** Type C DPA variation was noticed as most common variation with prevalence of 21.7%, followed by Type F with prevalence of 21.1%. Other variations of DPA were less commonly noticed. **Conclusion:** Precise knowledge about DPA variations is needed for surgeons particularly reconstructive surgeons and vascular surgeons to do their procedures successfully. So, we recommend the surgeons to undergo radiographic analysis of vascular anatomy prior to surgery.

## INTRODUCTION

Anterior tibial artery descends down in the ventral aspects of ankle joint and continues as Dorsalis pedis artery (DPA). It runs along the medial aspects of dorsum of foot and reaches first intermetatarsal space. Later it ends by branching into first dorsal metatarsal artery and deep plantar artery.[1] Deep plantar artery anastomosis with lateral plantar artery in sole and completes the plantar arch. DPA branches are lateral and medial tarsal arteries, arcuate artery, dorsal metatarsal arteries and cutaneous arteries.[2] DPA and its branches supplies bones and joints of foot, extensor hallucis brevis, extensor digitorum brevis, dorsal interosseous muscles, skin and fascia of dorsum of foot.[3]

As DPA is running between the extensor hallucis longus tendon and first tendon of extensor digitorum longus, the pulse of the same is felt by clinicians to determine blood flow to the foot.[1] Absence of DPA pulse may lead to necrosis and gangrene of the foot and it is more common in vaso-occlusive diseases of lower limb like thromboangitis obliterans, thrombosis etc.[4] Moreover, in children DPA arterial pulse absence results in contracture and growth retardation of foot.[5] DPA flap is commonly used by the reconstructive surgeons to repair the tissues damaged during road traffic accidents or in case of electric burns.[6,7] First dorso metatarsal artery is used as arterial pedicle in toe to finger transplant.[8,9] DPA fasciocutaneous flap is used to repair the oral cavity defects.[10] DPA has extensive variations, which was reported by Anatomists.[11] Documented DPA variations was DPA originated from perforating branch of peroneal artery, Double DPA, Lateral deviation of DPA, DPA branching into medial and lateral branches, DPA ending in second metatarsal space, DPA absent, Arcuate artery absent and Dorsal metatarsal arteries variations in origin.[12-14]

Knowledge about above mentioned DPA variations is important for vascular surgeons, angiographers, plastic surgeons and orthopedicians to do their procedures without complications.[12,15-16] As empirical evidences reported wide range of variations in DPA, the aim of our study was to perform a meta-analysis on reported DPA variations.

## MATERIALS AND METHODS

### Search Method

In order to collect the data related to DPA variations, a thorough search was done through electronic databases like Medline, PubMed central, Scopus, Embase, Web of science and ScienceDirect from January 2020 to August 2022. While performing the search following key words were used dorsalis pedis


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artery, lateral tarsal artery, medial tarsal artery, arcuate artery, first dorsal metatarsal artery, tarsal artery, plantar artery, foot arteries, arterial anatomy, pedal artery, artery of dorsum of foot, anterior tibial artery, cadaveric study of DPA, foot anatomy, vascular anatomy of foot, peripheral pulse, DPA variations, peripheral vascular diseases, foot surgery, flap reconstruction, myocutaneous flaps and DPA flaps.

In addition, a reference search was done in all the studies included in this meta-analysis, to explore further DPA related articles. Year and language limit was not applied as filter. Preferred Reporting Items for Systematic Reviews and Metanalysis (PRISMA) guidelines were followed during this meta-analysis.

**Inclusion Criteria**

Two independent reviewers assessed the eligible criteria for this metanalysis study. All full text cadaveric studies related to DPA variations from which relevant anatomical data could be extracted were included.

**Exclusion Criteria**

DPA variation studies that were not cadaveric studies nor full-text articles were excluded. DPA variation cadaveric studies from which relevant anatomical data cannot be extracted were excluded. In addition, full text DPA variation cadaveric studies with insufficient data, congenital foot pathologies, case reports, case series, letter to editor, conference abstracts, animal studies, textbooks and radiological studies were also excluded from this meta-analysis.

**Extraction of Data**

All DPA data like DPA origin, course and branching pattern variations were extracted by two reviewers individually [Figure 1]. If any queries in data, corresponding author of the respective study was contacted for clarification.

**Statistical Analysis**

All the data collected was pooled into Microsoft Excel sheet. Mean was calculated for the data and depicted in percentage. Confidence interval was calculated to find the range of values for the population mean.

## RESULTS

Overview of Meta-analysis study process is summarised in [Figure 1]. After intensive search of databases mentioned in this study, 11120 articles were revealed. In addition, 52 articles were identified through reference search. From 11172 articles, 8574 articles were obtained after removal of duplication. Out of 8574 articles, 8460 articles were excluded as it was not a cadaveric study nor a full text article. Finally, after screening 114 articles were full text articles, of which 25 articles fulfilled the eligibility criteria and it was included in this meta-analysis.

In this meta-analysis 25 eligible cadaveric studies (n= 1291 lower limbs) were included.[1-2,4,11,14,17-36] Year of included studies ranged from 1984 to 2022. Racial variations were also noticed in the included studies and reported from Asia, Africa, Europe and North America. [Table 1]

Variations in the origin of DPA was reported in 25 studies (n= 1291 lower limbs).

In our analysis, Type A was considered as usual Anatomy of DPA with prevalence of 57.5%. Type C DPA variations was noticed as most common variation with prevalence of 21.7% (95% Confidence Interval 21.1-22.2). Type F was noticed as second common variation of DPA with prevalence of 21.1%. Type D pattern was the third commonest DPA variation with prevalence of 13.7%. Type G (9.1%), Type B (7.4%), Type E (5.6%), Type H, Type I and Double DPA with prevalence of 2.2%. Racial variations and confidence interval of DPA were shown in [Figure 2-7].

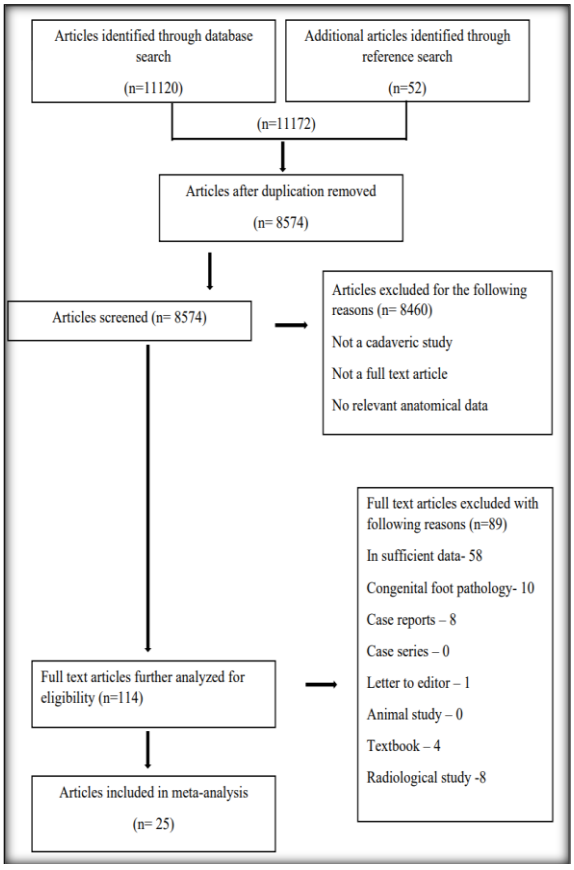


**Figure 1: PRISMA-Preferred reporting items for systematic reviews and meta-analyses flowchart of DPA articles identification included in the meta-analysis**

**Table 1: Characteristics of included studies**

| Study | Country | Type of study | No. of Lower limbs |
|---|---|---|---|
| Tonogai I et al. 2022,[17] | Japan | Cadaver | 29 |
| Hemamalini et al. 2021,[2] | India | Cadaver | 40 |
| George A et al. 2020,[4] | India | Cadaver | 50 |


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|---|---|---|---|
| Gautam A et al. 2020,[18] | Nepal | Cadaver | 30 |
| T. Sadeesh et al. 2020,[19] | India | Cadaver | 46 |
| Barot BJ et al. 2019,[20] | India | Cadaver | 40 |
| Chepte AP et al. 2018,[21] | India | Cadaver | 60 |
| Luckrajh JS et al. 2018,[22] | South Africa | Cadaver | 40 |
| Gupta C et al. 2018,[23] | India | Cadaver | 30 |
| Ntuli S et al. 2017,[1] | South Africa | Cadaver | 33 |
| Parikh S et al. 2017,[24] | United Kingdom | Cadaver | 19 |
| Vengadesan B et al. 2017,[25] | India | Cadaver | 40 |
| Awari P et al. 2016,[26] | India | Cadaver | 50 |
| Fernandes SJ et al. 2016,[27] | India | Cadaver | 50 |
| Kumari M et al. 2016,[28] | India | Cadaver | 40 |
| Rajeshwari MS et al. 2013,[29] | India | Cadaver | 42 |
| Sawant SP et al. 2013,[30] | India | Cadaver | 100 |
| Singh BN et al. 2013,[31] | United states of America | Cadaver | 20 |
| Kulkarni V et al. 2012,[32] | India | Cadaver | 33 |
| Vijayalakshmi S et al. 2011,[33] | India | Cadaver | 50 |
| Ebrahim M et al. 2008,[34] | Egypt | Cadaver | 20 |
| Vazquez T et al. 2006,[11] | England | Cadaver | 300 |
| Lee JH et al. 1996,[35] | Germany | Cadaver | 32 |
| Yamada T et al. 1993,[36] | United states of America | Cadaver | 30 |
| Bailleul JP et al. 1984,[14] | France | Cadaver | 67 |

**Table 2: Prevalence of DPA and its variations [1,2,4,11,14,17-36]**

| Population | Africa | Asia | Europe | North America | Present Meta-analysis |
|---|---|---|---|---|---|
| No. of Cadaveric Studies (No. of lower limbs) | 2 (73) | 17 (750) | 4 (418) | 2 (50) | 25 (1291) |
| Type A [%] (95% CI) | 39.4 (28.4-51.8) | 72.7 (71.1-74.2) | 56.9 (52-61.7) | 61.1 (47.1-75.3) | 57.5(56.8-58.1) |
| Type B [%] (95% CI) | 5.5 (1.5-13.4) | 8.4 (7.6-9.1) | 8.9 (6.3-11.9) | 6.7 (1.2-16.5) | 7.4 (7.3-7.4) |
| Type C [%] (95% CI) | 23.8 (14.1-34.6) | 8.4(8.06-8.7) | - | 33 (21.2-48.7) | 21.7 (21.1-22.2) |
| Type D [%] (95% CI) | 9.8 (3.9-18.7) | 17.7 (16.6-18.7) | - | - | 13.7 (13.4-13.9) |
| Type E [%] (95% CI) | 8.6 (3.08-17.14) | 3.8 (3.76-3.8) | 4.3 (2.5-6.7) | - | 5.6 (5.4-5.7) |
| Type F [%] (95% CI) | 8(3.08-17.14) | 9.6(9.04-10.15) | 31.8(27.3-36.5) | 35(22.9-50.8) | 21.1(21-22.3) |
| Type G [%] (95% CI) | 5.5(1.5-13.4) | 12.8(11.4-14.1) | - | 6.7(1.2-16.5) | 9.1(8.9-9.3) |
| Type H [%] (95% CI) | 2.7(0.3-9.5) | 1.8(1.7-1.8) | - | - | 2.2(2.1-2.2) |
| Type I [%] (95% CI) | 2.7(0.3-9.5) | 1.8(1.7-1.8) | - | - | 2.2(2.1-2.2) |
| Double DPA [%] (95% CI) | - | 2.2(2.1-2.2) | - | - | 2.2(2.1-2.2) |

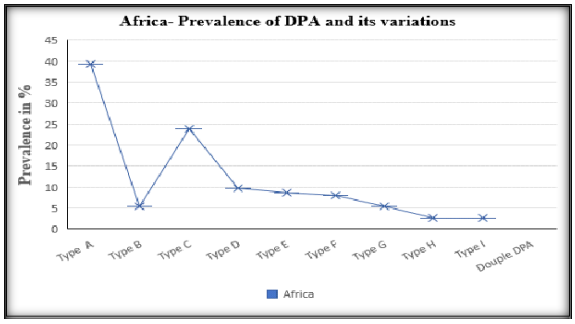


**Figure 2: Africa- Prevalence of DPA and its variations.[1,22]**

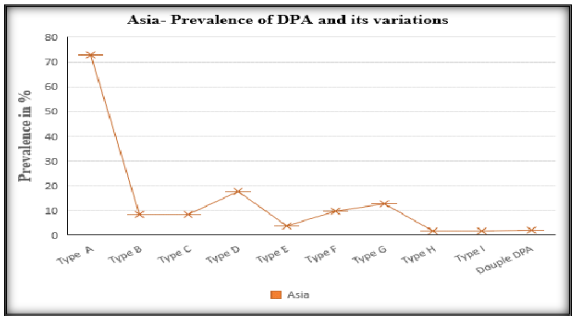


**Figure 3: Asia- Prevalence of DPA and its variations.[2,4,17-23,25-30,32-34]**

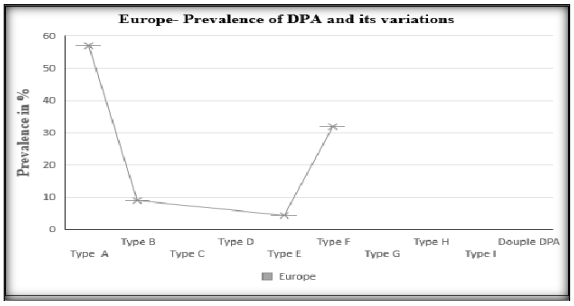


**Figure 4: Europe- Prevalence of DPA and its variations.[11,14,24,35]**

Type A- DPA showing standard vascular pattern, Type B- DPA absent, Type C- Arcuate artery absent, Type D- Arcuate artery absent with variations in number of lateral tarsal arteries, Type E- Variation in origin of second dorsal metatarsal artery, Type F- DPA with variations in branches, Type G- Variation in origin of DPA and lateral tarsal arteries, Type H- Poorly formed DPA and lateral tarsal arteries ,Type I- Arcuate artery forming U shaped loop and Double DPA- Anterior tibial artery divides into 2 DPA.[1,2] CI- Confidence Interval.


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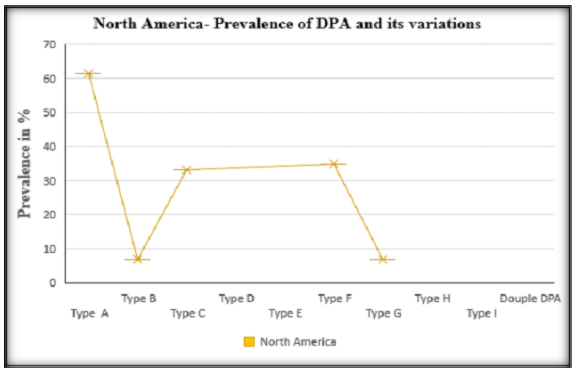


**Figure 5: North America- Prevalence of DPA and its variations.[31,36]**

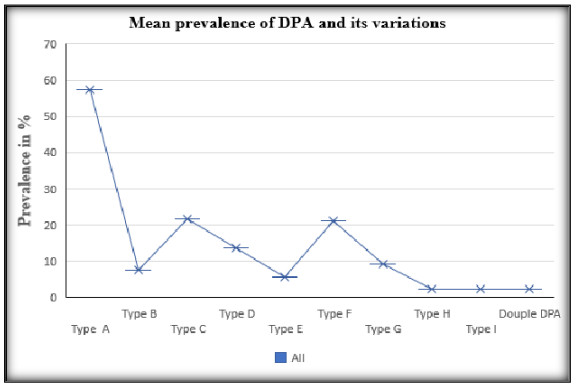


**Figure 6: Mean prevalence of DPA and its variations.[1,2,4,11,14,17-36]**

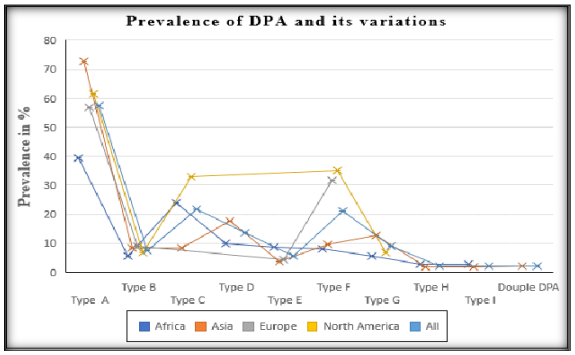


**Figure 7: Prevalence of DPA and its variations.[1,2,4,11,14,17-36]**

## DISCUSSION

Development of vascular system depends on vasculogenesis and angiogenesis. The process in which angioblast and hemangioblast cells develops into vascular tubes filled with blood to form vessels is termed as vasculogenesis.[37,38] Existing vessels sprouts into new blood vessels, such process is termed as angiogenesis. Vasculogenesis and angiogenesis depends on organ specific differentiation of vessels which includes vessels regression, cell retraction, migration of endothelial cells and selective apoptosis.[39-41]

Interplay between vascular endothelial growth factor, inhibitors, signalling pathway and hedgehog protein results in the formation of vascular system. Any failure in above mentioned regulations or genetic predisposition may lead to vascular variations like persistent of primitive arterial segments, hypoplasia, aplasia, abnormal fusions and duplication.[39,41-42]

Anatomical variations of arteries in lower limbs are very common and such variations can impact the success rate of surgeries. DPA is the major source of blood supply to the foot.[2] Precise knowledge about DPA is utilised in performing various procedures like bypass grafting, transluminal angiography, surgical repair of club foot and embolectomy.[4] Awareness about usual and aberrant anatomy of DPA and its branches helps the clinicians during their practice. So, in our study all the feasible data related to DPA variations were gathered from literature, analysed and reported.

In our analysis, Type A was considered as usual Anatomy of DPA with prevalence of 57.5%. When comparing the racial data, studies reported from Asia has the highest prevalence of (72.7 %) Type A pattern of DPA.[2,4,17-23,25-30,32-34] On the other hand, African studies showed the least prevalence of (39.4%) Type A pattern of DPA [1,22]. With respect to variations in DPA, in our meta-analysis, Type C pattern was noticed as most common variation with prevalence of 21.7%. When comparing the racial data related to Type C variation of DPA, studies reported from North America,[31,36] and Africa,[1,22] showed prevalence of 33% & 23.8% respectively. Type F was noticed as second common variation of DPA with prevalence of 21.1% (95% Confidence Interval 21-22.3). Studies from Europe,[11,14,24,35] showed Type F prevalence of 31.8%. Type D pattern was the third commonest DPA variation with prevalence of 13.7%. Type G (9.1%), Type B (7.4%), Type E (5.6%), Type H, Type I and Double DPA with prevalence of 2.2%. Type D, H, I & double DPA variations was not noticed in Europe,[11,14,24,35] and North America.[31,36] Studies from Asia showed variations of all types of DPA.[2,4,17-23,25-30,32-34]

In our study we didn't analysis the DPA variations data with respect to gender of the cadaver and side of the lower limb as there was lack of studies related to the same. We suggest the researchers to do more studies focusing on gender and side variations of DPA, which will be more beneficial to surgeons to determine which gender and side will be more commonly variable related to DPA.

## CONCLUSION

Empirical evidences till date reported many variations in DPA. The most common type of DPA variations reported through this metanalysis is Type C with the prevalence of 21.7%, followed by Type F with prevalence of 21.1%. As accurate knowledge about prevalence rate of DPA variations is needed for surgeons particularly reconstructive surgeons and vascular surgeons to do their surgical procedures without major complications. Thus, we suggest radiographic analysis of vascular anatomy prior to any surgical procedures in patients particularly in the foot region to get awareness about DPA variations.


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**Contribution of Authors**

1. Dr. K. Nirmal Kumar (first author) - Organized, analyzed, and wrote the manuscript.
2. Dr. P. Kalyana Panchakshari (second author) and Dr. K. Srikanth (corresponding author)- Worked on Preferred Reporting Items for Systematic Reviews and Metanalysis (PRISMA) guidelines to collect the DPA articles, assessed the eligible criteria for the metanalysis and extracted the data.
3. Dr. K. Srikanth (corresponding author)- Selecting the best journals, submitting and following up on the research articles.

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