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Research Article

Anatomical Study of the Formation, Completeness, and Variations of the Plantar Arterial Arch in Human Cadaveric Lower Limbs

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I N F O

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A B S T R A C T

Introduction: The plantar arterial arch is an important vascular structure in the sole of the foot, primarily formed by the lateral plantar artery and the deep plantar branch of the dorsalis pedis artery. Knowledge of its variations is essential for surgical procedures involving the foot, including vascular, reconstructive, and diabetic foot surgeries. This study was conducted to evaluate the formation patterns, completeness, and branching variations of the plantar arterial arch through cadaveric dissection.

Materials and Methods: This descriptive observational study was conducted on 50 formalin-fixed adult human cadaveric lower limbs in the Department of Anatomy at [Insert Institution Name], following institutional ethical approval. Standard dissection techniques were employed to expose and study the plantar arterial arch, with specific attention to its formation, completeness, contributing arteries, and the branching pattern of plantar metatarsal arteries. Findings were classified according to Sarrafian's classification into Types A to F and documented through photographs and descriptive records.

Results: A complete plantar arterial arch was observed in 44 specimens (88%), while 6 specimens (12%) showed incomplete arches. The lateral plantar artery was the dominant contributor in 28 limbs (56%), the deep plantar branch of the dorsalis pedis artery in 12 limbs (24%), and equal contributions were seen in 10 limbs (20%). Type C (24%) and Type B (20%) were the most common patterns observed. The fibular plantar marginal artery was present in 92% of cases.

Conclusion: The study reaffirms the predominance of complete plantar arterial arches and lateral plantar artery dominance, highlighting the clinical relevance of understanding these anatomical variations for surgical safety and planning.

Keywords: Plantar Arterial Arch, Lateral Plantar Artery, Deep Plantar Branch, Dorsalis Pedis Artery, Sarrafian Classification, Cadaveric Study, Vascular Anatomy, Foot Surgery, Anatomical Variation

Introduction

The architecture of the foot is uniquely designed to support its weight-bearing and locomotor functions through a complex interplay between its skeletal, muscular, and vascular components. Among these, the vascular supply plays a critical role in maintaining the viability and functional integrity of the tissues of the foot. The arterial supply to the sole of the foot is chiefly derived from three principal sources: the deep plantar branch of the dorsalis pedis artery (DPA), the lateral plantar artery (LPA), and the medial plantar artery (MPA).[1,2] Of particular clinical and anatomical significance is the plantar arterial arch (PAA), which is typically formed through the anastomosis of the lateral plantar artery (a terminal branch of the posterior tibial artery) with the deep plantar branch of the dorsalis pedis artery.[1,2] This arch gives rise to the plantar metatarsal arteries, which supply the toes, and also provides the fibular plantar marginal artery (FPMA) to the lateral aspect of the fifth toe.[3,4]

Anatomical studies have consistently demonstrated that the plantar arterial arch exhibits considerable variation in its formation, completeness, and the dominance of contributing arteries.[1,5] These variations are clinically significant, particularly in the context of vascular reconstructive procedures, flap surgeries, and interventions for peripheral arterial diseases of the foot.[5,6] Moreover, detailed knowledge of these vascular patterns is crucial during surgical procedures involving diabetic foot care, trauma surgery, and osteotomies of the forefoot, as inadvertent injury to these vessels can compromise tissue viability.[6]

Previous classifications, such as that proposed by Sarrafian, have detailed six distinct patterns of plantar arterial arch formation (Types A–F) based on the origin of the plantar metatarsal arteries and the relative contribution from the dorsalis pedis and lateral plantar arteries.[3] These range from configurations where the dorsalis pedis artery solely forms the arch and supplies all metatarsal arteries, to patterns where the lateral plantar artery alone contributes to the entire arch and its branches.[1,3,4,5] Despite these classifications, there remain discrepancies in the reported prevalence of these variations across different populations.[1,5,7-10] Additionally, there is a paucity of comprehensive anatomical studies documenting these variations in detail, especially in cadaveric populations, which could serve as reliable anatomical references for clinicians.

Given this background, the present study was undertaken to provide a detailed analysis of the formation patterns, completeness, and branching variations of the plantar arterial arch through cadaveric dissection. By documenting these variations systematically, this study aims to enhance anatomical knowledge pertinent to surgical planning, minimize the risk of vascular complications during foot surgeries, and provide valuable data for radiological interpretation of vascular imaging in the foot.

Materials and Methods

Study Design and Setting

This study was conducted in the Department of Anatomy. The aim was to observe and document the formation patterns and branching variations of the plantar arterial arch through cadaveric dissection.

Sample Size

The study included a total of 50 formalin-fixed adult human cadaveric lower limbs. Only cadavers with intact vascular anatomy of the lower limb and without any gross pathological or traumatic changes were selected.

Inclusion Criteria

Adult human cadavers of either sex.

Lower limbs with well-preserved vascular structures.

Absence of deformities, trauma, or prior surgical interventions involving the plantar aspect of the foot.

Exclusion Criteria

Cadavers with mutilated feet or damaged vascular anatomy.

Presence of any gross pathology or anatomical deformity affecting the lower limb or plantar region.

Dissection Procedure

Routine anatomical dissection techniques were employed to expose the arterial supply of the sole. A midline incision was made extending from the heel to the base of the toes. The skin, subcutaneous tissue, and plantar fascia were carefully reflected to expose the deeper vascular structures. Both sharp and blunt dissection methods were utilized to trace and preserve the continuity of the vascular network.

The lateral plantar artery (a terminal branch of the posterior tibial artery), deep plantar branch of the dorsalis pedis artery, and medial plantar artery were identified and followed distally. Particular attention was given to documenting the formation of the plantar arterial arch, its completeness, contributing arteries, and the origin of the plantar metatarsal arteries and fibular plantar marginal artery.

Classification of the Plantar Arterial Arch

The observed patterns were classified according to the system proposed by Sarrafian,[3] which categorizes the plantar arch into Types A to F, based on the contribution of the lateral plantar artery and dorsalis pedis artery to the plantar metatarsal arteries.

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Data Collection and Analysis

Findings were recorded through detailed diagrams, high-resolution photographs, and descriptive notes during the dissections. Data were analysed descriptively and expressed as frequencies and percentages. Given the anatomical and observational nature of this study, no inferential statistical tests were performed.

Ethical Considerations

All cadaveric materials used in this study were handled with respect and dignity, in accordance with ethical standards for anatomical research and the principles of the Declaration of Helsinki. Institutional Ethical Committee approval was obtained prior to the initiation of the study.

Results

Formation of Plantar Arterial Arch

In the present study involving 50 formalin-fixed adult human cadaveric lower limbs, the formation of the plantar arterial arch was evaluated through meticulous dissection. It was observed that the plantar arterial arch was complete in 44 specimens (88%), where there was a continuous anastomosis between the lateral plantar artery and the deep plantar branch of the dorsalis pedis artery. In contrast, incomplete arches were found in 6 specimens (12%), where the continuity between the contributing arteries was absent Table 1.

Table 1.Completeness of Plantar Arterial Arch

n = 50

Completeness	Number of Limbs	Percentage (%)
Complete	44	88%
Incomplete	6	12%
Total	50	100%

Contribution of Arteries to Formation of the Arch

On analysing the arterial dominance contributing to the formation of the plantar arterial arch, it was found that in 28 limbs (56%), the formation of the arch was predominantly from the lateral plantar artery. In 12 specimens (24%), the deep plantar branch of the dorsalis pedis artery was the dominant contributor. An equal contribution from both arteries was observed in 10 specimens (20%) Table 2.

Classification of Plantar Arterial Arch (According to Sarrafian)

Based on Sarrafian's classification, in the table 3, the plantar arterial arch in the specimens was categorized into six types. Type A configuration, where the arch was formed solely by the deep plantar branch of the dorsalis pedis artery supplying all four plantar metatarsal arteries and the fibular plantar marginal artery, was observed in 6 specimens (12%). Type B pattern, where the union occurred at the fourth metatarsal artery level and the dorsalis pedis artery supplied all plantar metatarsal arteries, was noted in 10 specimens (20%). Type C pattern, with union between the third and fourth plantar metatarsal arteries and contributions from both dorsalis pedis and lateral plantar arteries, was the most frequent and was found in 12 specimens (24%). Type D, where the union occurred between the second and third metatarsal arteries with dorsalis pedis supplying the first and second arteries and lateral plantar supplying the others, was noted in 8 specimens (16%). Type E pattern was observed in 4 specimens (8%), where the dorsalis pedis artery contributed only to the first metatarsal artery. Finally, Type F, where the arch was entirely formed by the lateral plantar artery supplying all plantar metatarsal arteries, was seen in 10 specimens (20%).

Prevalence of Branching Patterns

The fibular plantar marginal artery (FPMA) was identified in a well-developed form in 92% of the specimens. The number of plantar metatarsal arteries consistently ranged between four and five, with the fourth plantar metatarsal artery most commonly originating from the lateral plantar artery in cases with incomplete arches.

Summary of Findings

Overall, this study demonstrated that a complete plantar arterial arch was present in the majority (88%) of specimens. Type C and Type B configurations were found to be the most common patterns in this population. Additionally, the lateral plantar artery was dominant in more than half of the specimens (56%), while exclusive dominance of the deep plantar branch of the dorsalis pedis artery was relatively less common.

Table 2.Arterial Contribution to Formation of Plantar Arterial Arch

n = 50

Dominant Artery	Number of Limbs	Percentage (%)
Lateral Plantar Artery Dominance	28	56%
Dorsalis Pedis (Deep Plantar Branch) Dominance	12	24%
Equal Contribution	10	20%
Total	50	100%

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Table 3.Classification of Plantar Arterial Arch (According to Sarrafian)

n = 50

Type	Description	Number of Limbs	Percentage (%)
Type A	Arch formed solely by dorsalis pedis supplying 1-4 plantar metatarsal arteries and FPMA	6	12%
Type B	Union at 4th metatarsal artery, dorsalis pedis supplies arteries 1-4	10	20%
Type C	Union between 3rd-4th metatarsal arteries, dorsalis pedis supplies 1-3, lateral plantar artery supplies 4th and FPMA	12	24%
Type D	Union between 2nd-3rd metatarsal arteries, dorsalis pedis supplies 1-2, lateral plantar supplies 3-4 and FPMA	8	16%
Type E	Union between 1st-2nd metatarsal arteries, dorsalis pedis supplies only 1st artery	4	8%
Type F	Arch formed solely by lateral plantar artery supplying all arteries	10	20%
Total		50	100%

Discussion

In the present study, the plantar arterial arch was found to be complete in 44 specimens (88%) and incomplete in 6 specimens (12%). These findings are in concordance with the observations of Kalicharan et al. (2015)[11] who reported a high prevalence of complete plantar arterial arches in 90% of specimens in their cadaveric study. Similarly, Ozer et al. (2005)[12] observed that the majority of cases showed a complete arch, accounting for 85%, confirming the anatomical reliability of the plantar arch as a vascular source for the plantar region. The presence of an incomplete arch in 12% of cases in the present study is also comparable to the findings of Ozer et al. (2005)[12] who documented incomplete arches in 15% of their specimens. These variations are of critical importance in surgical procedures like flap harvesting and revascularization where predictable vascular anatomy is essential.

In the present study, the lateral plantar artery was the dominant contributor in 56% of specimens, while the deep plantar branch of dorsalis pedis artery contributed dominantly in 24%, and equal contribution was observed in 20% of cases. This is in line with the findings of Kalicharan et al. (2015)[11] who documented lateral plantar artery dominance in approximately 60% of cases and a significant contribution from the dorsalis pedis in about 20% of cases. Ozer et al. (2005)[12] similarly reported lateral plantar artery dominance in 58% of their dissections, suggesting this pattern is a consistent anatomical feature across populations. These observations reinforce the clinical understanding that the lateral plantar artery plays a primary role in plantar circulation, a fact utilized in flap designs and surgical planning for plantar defects.

According to Sarrafian's classification, the present study noted Type C (24%) and Type B (20%) as the most common patterns, followed by Type F (20%), Type D (16%), Type A (12%), and Type E (8%). These findings demonstrate the prevalence of mixed contributions (Type C and B) and lateral plantar dominance (Type F), aligning with the patterns identified by Ozer et al. (2005)[12] who reported similar dominant configurations of Types B, C, and F in their anatomical series. In the study by Kalicharan et al. (2015)[11] Types B and C were also frequently noted as common variations, emphasizing the consistent anatomical variability of this arch across different populations. These findings are of particular relevance in vascular reconstruction surgeries where knowledge of these dominant patterns helps guide anastomotic strategies.

In the current study, the fibular plantar marginal artery (FPMA) was present and well-developed in 92% of cases. The number of plantar metatarsal arteries consistently ranged between four and five, with the fourth metatarsal artery frequently arising from the lateral plantar artery in incomplete arches. These observations corroborate the findings from Sebastien et al. (2004),[13] who highlighted the consistency of these branches in vascular imaging, particularly in diabetic patients undergoing contrast-enhanced MR angiography for foot circulation assessment.

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Such anatomical consistency underlines the importance of these vessels in limb salvage procedures, as previously discussed in vascular studies by Hughes et al. (2004)[14] where the plantar arch and its branches were effectively utilized for bypass procedures. Furthermore, Strauch et al. (1990)[15] and Meyer (1983)[16] emphasized the surgical significance of predictable plantar vasculature in reconstructive microsurgery for innervated flap transfers and limb salvage.

The frequent presence of the FPMA aligns with the surgical applications discussed by Foucher et al. (1985)[17] who utilized plantar arteries, including the marginal arteries, in complex composite tissue transfers from the foot to the hand.

Conclusion

The present cadaveric study evaluated the formation, completeness, and branching patterns of the plantar arterial arch in 50 formalin-fixed adult human lower limbs. A complete plantar arterial arch was observed in 88% of specimens, while 12% were incomplete. The lateral plantar artery was the dominant contributor in 56% of cases, the deep plantar branch of the dorsalis pedis artery in 24%, and equal contributions in 20%. According to Sarrafian's classification, Type C (24%) and Type B (20%) were the most common patterns, followed by Type F (20%), Type D (16%), Type A (12%), and Type E (8%). The fibular plantar marginal artery was present in 92% of specimens, and the plantar metatarsal arteries consistently ranged between four and five in number. These findings align with previous studies, confirming the predominance of complete arches and lateral plantar artery dominance. Awareness of these variations is crucial for surgical planning in reconstructive, vascular, and diabetic foot surgeries to minimize vascular complications and improve outcomes.

Limitations of the Study

This study was conducted on a limited sample size of 50 formalin-fixed cadaveric lower limbs from a specific geographical population, which may not fully represent the anatomical variations found in broader or more diverse populations. Additionally, factors such as age, sex, and comorbidities of the cadavers were not considered, even though these variables might influence vascular anatomy. The study relied solely on gross anatomical dissection without the use of radiological imaging, vascular injection techniques, or histological analysis, which could have provided more detailed visualization of finer vascular structures. Furthermore, as the dissections were performed on formalin-fixed specimens, the potential impact of post-mortem changes and fixation artifacts cannot be completely excluded. Finally, this study did not correlate anatomical findings with clinical or surgical outcomes, which limits the direct applicability of these observations in surgical practice without further clinical validation.

Conflict of Interest: None

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Author's Contribution: All authors are equally contributed

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