

Anatomical Study of Arterial Plantar Arch and its Clinical Significance

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The study aimed to examine the morphology of the plantar arterial arch and determine the dominant variants of the plantar arch. On twenty-two dissected lower limbs the origin, course, and branches of the arteries in the plantar part of foot were examined. The plantar arterial arch was observed to be fully developed in all specimens with variations found in 5 (22.7%) of the limbs. The plantar arterial arch was mostly located in the anterior middle in 18 (81.8%) cases, in the junction between the anterior middle and intermediate middle in four (18.2%) cases. Normal course of lateral and medial plantar arteries was found in 17 cases (77.3%). In one case (4.5%) the deep plantar arch originated from dorsalis pedis artery and partly lateral plantar artery. In one case (4.5%) the lateral plantar artery gave origin to the third and fourth metatarsal arteries and in three cases (13.6%) the lateral plantar artery gave off the second, third and fourth metatarsal arteries. The data from the study indicate that the plantar arch is a regular finding, but variants in terms of origin, formation and branching are not an unusual finding. Thorough knowledge of the blood supply to the foot is essential for surgeons in the mobilization and application of plantar flaps.

Key words: plantar arterial arch, morphology, variations, plastic surgery

Introduction

Reconstruction of the arteries of the foot in patients with severe chronic arterial occlusive disease has become a routine and valuable procedure. However, it is frequently difficult to select the optimal site for the distal arterial anastomosis [7]. Hence, accurate knowledge of the arterial patterns and variations becomes necessary in reconstructive surgery. The origin, course and branching of the plantar arch is essential as it forms the stem of one of the major musculo-cutaneous flaps used in reconstructive foot surgery.

Although the arterial anatomy of the foot has been addressed in literature, more comprehensive studies of the plantar arch and its branches in terms of morphological and morphometric variations, are still insufficient [2, 4, 5, 6]. More recently Ozer et al. and Gabrielli et al. [2, 6], have shown the contributing arteries and the positioning of the plantar arch within the foot, documenting a few anatomical variations in this region. In 2008, Anupama investigated the plantar arterial arch in 50 formalin fixed cadavers, and

confirmed the findings of the above mentioned authors [5] and had not noted any further differences. Farlex (2014) confirmed the position of the plantar arterial arch within the foot as described by Ozer et al. and Gabrielli et al. [2, 6], but further refined it by stating that it lies on the transverse arch of the foot.

In order to determine the most important anatomic variations of the plantar arteries providing greater anatomical detail to vascular surgery, the anatomy and constitution of the deep plantar arch was studied.

Therefore, the aims of the study were to: a) re-examine and describe the morphology of the plantar arterial arch, and b) determine the dominant contributors to the plantar arch.

Material and Methods

On twenty-two dissected lower limbs the origin, course, and branches of the arteries in the plantar part of foot were examined.

The anatomy of the plantar arteries, their variations, origins, courses, and distributing branches were examined. The relations of the plantar arch were noted, and the entire plantar arterial arch was clearly defined. The plantar arch and its branches were exposed and photographed (iPhone6).

To determine the location of the plantar the sole of the foot was divided into three regions: anterior; middle; and posterior [3]. The middle was further divided into three parts: middle anterior; intermediate middle; and middle posterior (**Fig. 1**). The predominant blood supply to the plantar arch was determined by measuring each commissure along the plantar archcourse [1]. The diameter measurement as compared to the previous one determined the artery contributing to the dominating arterial supply.

Results

Posterior tibial artery

The posterior tibial artery runs between the superficial and deep muscles in the rear section of the lower leg. In downward direction it moves medially and can be palpable behind the medial malleolus. (**Fig. 2**)

The anatomy of the plantar arteries, their variations, origins, courses, and distributing branches were examined. The relations of the plantar arch were noted, and the entire plantar arterial arch was clearly defined. Once the entire course of the plantar arch was visible *in situ*, it was recorded and photographed (Samsung Galaxy Note 10.1 5 megapixel).

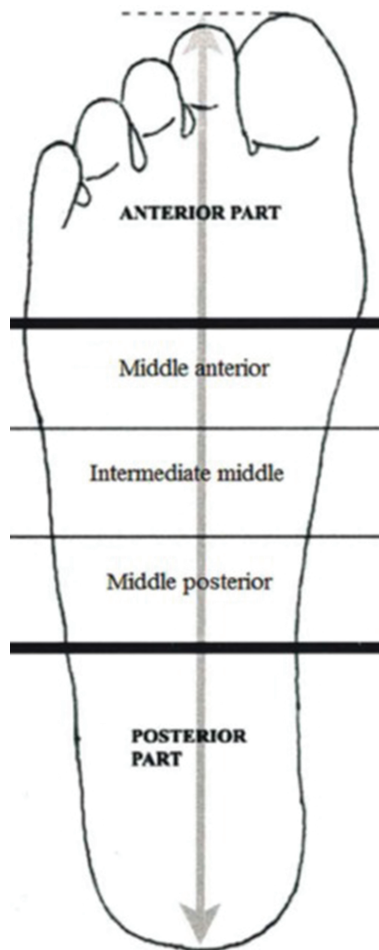


Fig. 1. Schematic representation of the different quadrants the plantar side of the right foot. (Adapted from Ozer *et al.*, 2005).



Fig. 2. Normal course of a. tibialis posterior behind the medial malleolus.

The location of the plantar arterial arch was determined by dividing the foot into three compartments: anterior; middle and posterior. The middle was further divided into three parts: middle anterior; intermediate middle; and middle posterior (**Fig. 1**). The length of the plantar arterial arch was measured from the point of anastomoses between the lateral plantar artery and the deep branch of the dorsalis pedis artery (**Fig. 2**). Predominant blood supply to the plantar arch was determined by measuring each commissure of the entire course of the plantar arch. A larger or smaller diameter as compared to the previous measurement determined which of the closest contributing artery, i.e the deep branch of dorsalis pedis artery, lateral plantar artery, or both, was responsible for the dominating arterial supply.

Branches in the ankle area

- Posterior medial malleolar artery- forms arterial network around the medial ankle
- Calcaneal rami – arterial network of the heel area
- Artery of tarsal canal - blood supply to the body of the talus

Branches in the foot

Below the sustentaculum tali posterior tibial artery divides into lateral and medial plantar arteries (**Fig. 3**)

On its course the lateral plantar artery gives off

- medial calcaneal branch (first clone) for the heel pad. Avulsion on the heel is a severe injury associated with high energy trauma and often with poor prognosis because of the possibility of heel pad necrosis
- branch to adductor digiti minimi muscles (second branch)
- digiti minimi artery (third branch)
- plantar arch (terminal branch). Plantar metatarsal arteries arise from the arch (**Fig. 4**)



Fig. 3. Tibialis posterior artery branching into lateral plantar and medial plantar arteries.



Fig. 4. Deep plantar arch – a terminal branch of lateral plantar artery.

Medial plantar artery runs along the medial edge of the foot and at the scaphoid / medial cuneiform bone divides into superficial and deep branch. The deep branch anastomoses with the first plantar metatarsal artery.

The Plantar Arterial Arch and Variations. The plantar arterial arch was observed in all of the specimens. It was found to be fully developed in all of the specimens as well (Fig. 3) with variations in 5 (22.7%) of the specimens.

Shape. In 3 (13.6%) of the specimens, a variation with the shape of the plantar arterial arch was observed. These variations were grouped as follows: a) Type A - Sharp irregular curve: observed on the left foot in one (4.5%) of the sample of variations (Fig. 4); b) Type B - Obtuse shaped curve: observed in six (4.5%) of the specimens, four right feet and two left feet (Fig. 5); and c) Type C - Spiral shaped arch: observed in one (4.5%) of the specimens (Fig. 6).

Location. The location of the plantar arterial arch was in the anterior middle in 18 (81.8%) cases, in the junction between the anterior middle and intermediate middle in four (18.2%) cases [3].

Formation. The results of this study are grouped as follows: Normal course of lateral and medial plantar arteries was found in 17 cases (77.3%) (Fig. 3). In one case (4.5%) the deep plantar arch originated from dorsalis pedis artery and partly lateral plantar artery (Fig. 5). In one case (4.5%) the lateral plantar artery gave off the third and fourth metatarsal arteries (Fig. 6). In three cases (13.6%) the lateral plantar artery gave off the second, third and fourth metatarsal arteries. (Fig. 7).

By changing lifestyle and increasing stress, people suffer more often from diseases such as diabetes and hypertension. Diabetic neuropathy leads to foot infections and ischemia, resulting in the risk of large amputations. In the effort to rescue the ischemic limb, the arterial bypass plays a major role. A. dorsalis pedis with the main and clones is preferentially used as a receptacle. A lumbar arthritis arterialized by a. dorsalis pedis can safely be used as an island flap to cover ankle or heel defects and as a free flap for palm defects. Therefore, a. A. dorsalis pedis.

Because variations in the plantar arch are not unusual, it is important to have in-depth anatomical knowledge of the arteries. Preoperative angiography for each anomaly is recommended to prevent risks during surgical intervention.



Fig. 5. Deep plantar arch formed by dorsalispedis artery and partly from lateral plantar artery.



Fig. 6. Division of a. tibialis posterior artery – plantar arch, medial plantar; plantar metatarsal arteries, lateral plantar arteries.



Fig. 7. Deep plantar arch giving off the second, third and fourth metatarsal arteries.

Conclusion

This study was designed to improve the understanding of the plantar arterial arch and its variations. Thorough knowledge of the blood supply to the foot is essential for surgeons in the mobilization and application of plantar flaps. The study findings complement the existing descriptions of the plantar arch with regard to morphology and variations in the formation.

The data from the study indicate that there is asymmetry in the plantar arch, which is largely related to its formation. On the other hand, the distances between plantar metatarsal arteries arising from arcus plantaris are variable. Some are close and others are at a greater distance; some arteries may arise even from the same point of the arch.

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