Anatomical Variations in Dorsal Metatarsal Arteries with Surgical Significance: A Cadaveric Study

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Abstract

Introduction: Based on angiosome concept to revascularize a particular artery, the microvascular and reconstructive surgeons must know the anatomy and variations in the arteries in that specific region of the body to achieve better results. Nowadays, dorsal metatarsal artery (DMTA) perforator flaps and toe grafts are becoming popular which also demand adequate information about normal anatomy and variants in these arteries for fruitful results. Materials and Methods: The authors studied normal anatomy and variations in the origin of DMTAs in 50 lower extremities of 25 embalmed cadavers. Results: The authors found many variations as the absence of DMTAs, origin of the DMTA from the deep plantar arch. The places wherever the arcuate artery was absent the lateral tarsal artery gave rise to dorsal metatarsal arteries. Conclusion: Being familiar with the incidence of anatomical variations in the origin of the DMTAs can increase vigilance in vascular and reconstructive surgeries leading to better prognosis. surgeries leading to better prognosis.

Keywords: Angiosome, dorsal metatarsal artery, microvascular, perforator flaps, reconstructive surgeries, toe grafts

INTRODUCTION

With the advancements in technologies, the microvascular and reconstructive surgeries have conferred a new face to the postoperative prognosis. The prerequisite for this furtherance is obtaining detailed anatomical knowledge about the area of interest. This really stimulates the anatomists to get into the minute anatomical details.

The area of interest of the authors is dorsal metatarsal arteries (DMTAs). Dorsalis pedis artery (DPA) gives out the arcuate artery (AA) from its lateral side which crosses across the bases of lateral four metatarsals. Then, the DPA passes to the first interosseous space, where it divides into the first metatarsal artery and a deep plantar artery. The AA gives rise to 2nd, 3rd, and 4th DMTAs opposite the bases of metatarsals.

Knowing anatomy and anatomical variants in origin of the DMTAs can help the endovascular surgeons to select the artery to be revascularized based on angiosome concept in critical limb ischemia cases to avoid amputation in diabetics foot.[1] It can also help in reconstructive surgeries to select the vascularized bone graft for reconstruction of metacarpals and digits of the amputated hand.[2] An individualized and well-planned reconstruction of the fingerless hand with toe-to-fingers transfer provides excellent restoration of hand function.[3]

Reconstruction of soft tissue defect of distal third of the lower limb is a challenge for surgeons. Various kinds of flaps based on DMTAs are still under invention. Knowledge about the anatomical variations in DMTAs can also help select the artery for pedicle-based flap to repair soft tissue defects in distal third of lower extremity.[4]

The reversed DMTA flap can be used to reconstruct the soft tissue defect of the big toe.[5]

MATERIALS AND METHODS

Fifty lower extremities of 25 cadavers from the department of Anatomy of Dr. D. Y. Patil Medical College, Hospital and Research Centre, Pune were dissected after embalming the cadavers with 10% formalin. The dissection was carried out by following dissection procedure as per Cunningham’s Manual-I, 15th edition. Skin of dorsum of the foot was reflected. After

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reflecting the deep fascia and extensor retinaculum the DPA was dissected and cleaned. Branches of DPA were exposed after reflecting the extensor digitorum brevis muscle. They were dissected and cleaned. The branches of AA, lateral tarsal artery (LTA) were dissected and cleaned. Any variations in the origin of the DMTAs were noted. Photographs were taken. Authors dissected 50 lower extremities to see the normal pattern and variations in the origin of DMTAs.

Observations
The authors dissected 50 lower extremities to see normal anatomy and variations in the DMTAs. The observations are tabulated in Table 1. In most of the cases, the 1st DMTA was a branch of the DPA. In 8% of cases, it was absent. In one leg, the DPA after giving rise to AA entered through the proximal part of the 1st intermetatarsal space to join the deep plantar arch without giving any 1st dorsal metatarsal branch. In this case, the 1st DMTA originated from deep plantar arch.

In cases where AA was incomplete or absent; the 2nd, 3rd, and 4th DMTAs were either arising from LTA or from the deep plantar arch. In 10% of cases, the 2nd DMTA was arising from DPA.

Discussion
The authors reviewed many articles which informed about branching pattern of DPA, but very few have mentioned about the incidence of variant origin of DMTAs.

Yeo et al. found that the 1st DMTAs was present in 100% specimens. Upton J found that the 1st DMTA was absent in 9% of cases. Hollinshead mentioned that the 1st DMTA sometimes arises from the plantar arch and is sometimes missing. In 2012, Kulkarni and Ramesh found that the 1st DMTA was absent in 33.3% cases. The authors found that the 1st DMTA was absent in 8% of feet [Figure 1] and in 2% of feet it took origin from deep plantar arch [Figure 2].

El Saeed et al. mentioned of the extra 1st DMTA as the branch of AA in 5% of cases.

Vijayalaxmi et al. in male cadaver found that in the right lower limb anterior tibial artery was dividing into three branches as LTA and two medial branches ran on the dorsum of foot to reach 1st intermetatarsal space. The lateral one passed through the 1st interosseous space in proximal aspect to join the plantar arch. The medial one continued as 1st DMTA.

El Saeed et al. found that 2nd, 3rd, and 4th DMTAs were arising from AA in 85% of cases. In present study, the 2nd, 3rd, and 4th DMTAs were seen arising from AA in 60%, 54%, and 40% cases, respectively [Figure 2].

Kumari and Bharati found that the 3rd and 4th DMTAs were arising from 2nd DMTA in 5% of cases. Hollinshead mentions that when the AA is rudimentary or missing the LTA may give rise to more lateral DMTAs.

In present study, authors observed that the 2nd DMTA was originating from DPA in 10% of feet [Figure 3], from deep plantar arch in 18% of feet [Figure 4], and from LTA in 10% of feet [Figure 5]. The 3rd DMTA was originating from deep plantar arch in 16% of feet [Figure 4] and from LTA in 22% of feet [Figure 6]. The 4th DMTA was originating from deep plantar arch in 24% of feet [Figure 4] and from LTA in 18% of feet [Figure 6].

Yeo et al. found that the 2nd, 3rd, and 4th DMTAs were present in 100% specimens.

Huber found that 2nd, 3rd, and 4th DMTAs were absent in 5%, 7.5%, and 17% of feet.

In present study, authors observed that the 2nd, 3rd, and 4th DMTs were absent in 2%, 8%, and 18% of feet, respectively [Figure 7].

Becoming aware of these variations, in the origin of the DMTAs can help reconstructive surgeries to select the appropriate pedicle-based graft either a myocutaneous flap or a bone graft.

Table 1: Variations noted in dorsal metatarsal arteries

| Name of the artery | Origin from | Features | Present |
|--------------------|-------------|----------|---------|
|                    | Dorsalis Pedis artery | Arcuate artery | Lateral tarsal artery | Deep plantar artery |
| 1st DMTA           | 8%          | 90%       | -       | -       | 2%     |
| 2nd DMTA           | 2%          | 10%       | 60%     | 10%     | 18%    |
| 3rd DMTA           | 8%          | -         | 54%     | 22%     | 16%    |
| 4th DMTA           | 18%         | -         | 40%     | 18%     | 24%    |

Figure 1: The red line shows absent 1st dorsal metatarsal artery
It also can help identify the topographical variations of DMTAs while doing angiography.

**Conclusion**

The DMTAs showed lot of variations in their origin. In most of the cases, the 1\textsuperscript{st} DMTA was given by DPA. The 2\textsuperscript{nd}, 3\textsuperscript{rd}, and 4\textsuperscript{th} DMTAs which were not given by AA were either branching from LTA or the deep plantar arch. Acquiring information about the incidence of anatomical variations in the origin of the DMTAs is one of the factors which can impart better prognosis after various microvascular and reconstructive surgeries. It also can help identify the variations of DMTAs while doing intraoperative angiography which can provide additional information for further planning in the surgery.

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**Conflicts of interest**

There are no conflicts of interest.

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