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Case Report

Anatomy Section

A Variant Dorsalis Pedis Artery and Its Relationship with the Deep Fibular Nerve

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ABSTRACT

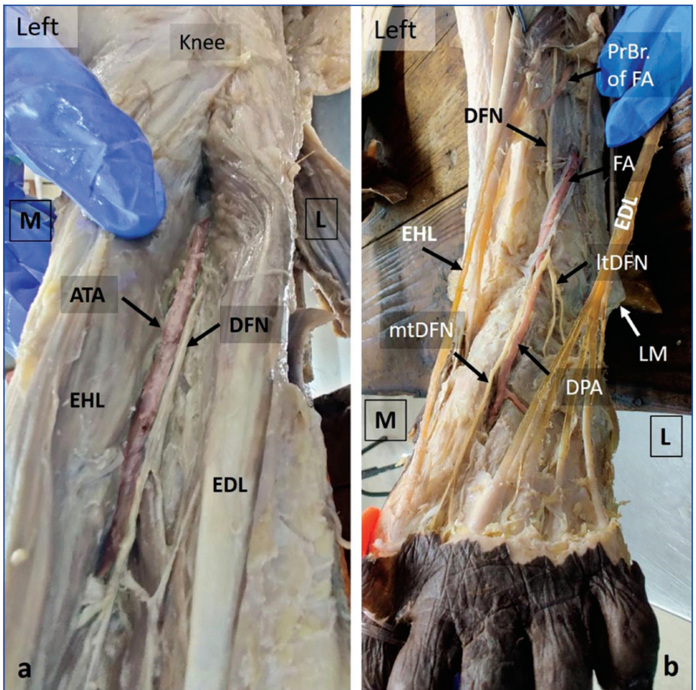
During a cadaveric dissection session, a distinctive neurovascular pattern was identified in the left leg of a 66-year-old female cadaver. The Anterior Tibial Artery (ATA), while maintaining a normal origin and luminal diameter, exhibited a shortened course, terminating in the upper third of the leg. In the lower third of the leg, the Fibular Artery (FA), known as the peroneal artery, traversed through the interosseous membrane to the anterior compartment, persisting as the Dorsalis Pedis Artery (DPA). The Deep Fibular Nerve (DFN), displaying a usual course in the upper two-thirds of the leg, crossed the variant DPA posteriorly and divided into two terminal branches on its posterolateral side. The medial terminal branch proceeded to cross the artery anteriorly within the anterior tarsal tunnel. This distinctive relationship between the DFN and the variant DPA renders the nerve susceptible to compression and may result in "anterior tarsal tunnel syndrome".

Keywords: Anterior tarsal tunnel, Anterior tibial artery, Compression, Fibular artery, Retinaculum

CASE REPORT

During the dissection of a 66-year-old female cadaver, a unilateral variation in the origin of the Dorsalis Pedis Artery (DPA) and its relation to the Deep Fibular Nerve (DFN), also known as the deep peroneal nerve, was observed in the left leg [Table/Fig-1]. In the popliteal fossa, the popliteal artery is divided into the ATA and Posterior Tibial (PTA) arteries, with a normal arterial pattern detected in the posterior compartment of the leg. The PTA gave off the FA, also known as the peroneal artery, supplying the lateral compartment of the leg and measuring 3.86 mm in external diameter. The ATA had a short course in the anterior compartment, terminating after giving off a few muscular branches in the upper one-third of the leg. Despite its short course, the ATA showed no signs of hypoplasia, measuring 3.3 mm in external diameter [Table/Fig-1a]. Vascular supply to the middle one-third of the leg was provided by a few perforating branches originating from the FA.

In the lower part of the leg, at 66.39 mm above the lateral malleolus, the FA passed through the interosseous membrane into the anterior compartment, replacing the ATA for a distance of 54.33 mm before continuing as the DPA [Table/Fig-1b]. The external diameter of FA in the anterior compartment was 3.4 mm. In the upper two-thirds of the leg, the DFN followed a typical course, descending beneath the extensor digitorum longus muscle. In the lower one-third of the leg, the DFN passed posterior to a small perforating branch from the FA, continued downwards, and contrary to its name, "nervus hesitans," crossed the FA posteriorly, from the medial to the lateral side. As the DFN wound around the artery, it divided into medial and lateral terminal branches on the posterolateral aspect, just above the malleoli. In the anterior tarsal tunnel of the dorsum of the foot, the medial terminal branch of the DFN (mtDFN) crossed the DPA anteriorly, positioning itself on its medial aspect and continued towards the first interosseous space where it terminated by dividing into two branches [Table/Fig-1b]. A normal neurovascular pattern was observed on the right-side, and the external diameters of the ATA, PTA, and FA were 3.5 mm, 3.62 mm, and 3.5 mm, respectively.



[Table/Fig-1]: a) Dissection of the anterior compartment of the leg in its upper one-third shows the Anterior Tibial Artery (ATA) with normal luminal diameter but a shortened course; (b) Dissection of the lower one-third of the leg and dorsum of foot showing the variant origin of Dorsalis Pedis Artery (DPA) from the Fibular Artery (FA) and its relation with DFN and mtDFN.
ATA: Anterior tibial artery; DPA: Dorsalis pedis artery; PrBr: Perforating branch; LM: Lateral malleolus; mtDFN: Medial terminal branch; ltDFN: Lateral terminal branch; EHL: Extensor hallucis longus; EDL: Extensor digitorum longus; M: Medial; L: Lateral

DISCUSSION

The popliteal artery and its branches provide the principal blood supply for the leg and foot. The ATA serves the extensor compartment, while the DFN runs along its lateral side in the proximal part of the leg. The DFN assumes an anterior position relative to the ATA in the middle third of the leg. Termed the "nervus hesitans," the nerve intriguingly hesitates to cross over the artery. This distinctive behaviour persists into the distal third of the leg, with the DFN consistently maintaining its lateral position in relation to the ATA [1].

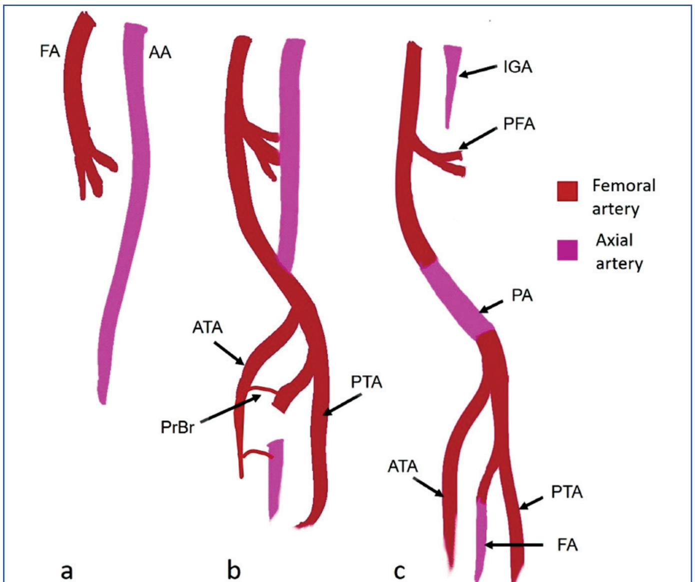
In the dorsum of the foot, the ATA transforms into the DPA and is accompanied by the mtDFN on its lateral side. The DPA courses toward the first intermetatarsal space and, by passing between the two heads of the first dorsal interosseous muscle, completes the plantar arch in the sole. Simultaneously, the PTA and FA supply the posterior and lateral compartments of the leg, respectively [1].

Variations in the anatomical vascular pattern significantly impact the success of vascular surgeries and interventional procedures. The branches emerging from the popliteal artery play a pivotal role in femorotibial arterial reconstructions and the creation of fasciocutaneous flaps [2,3]. The luminal diameter of the ATA is a crucial determinant in the patency rate of femorotibial arterial reconstructions [4]. In cases of a hypoplastic ATA or PTA, the anterior perforating branch of the FA tends to undergo enlargement to compensate and supply the respective areas. In such situations, harvesting the fibula along with the FA poses a risk to the blood supply to the foot [5].

Kim D et al., categorised the branching pattern of the popliteal artery into three types. The normal anatomical pattern with the popliteal artery dividing at the lower end of the popliteus muscle is type I, and the high branching of the popliteal artery is type II. The type III pattern, where one of the vessels is hypoplastic or aplastic, is further divided into three subtypes: Type III-A - the PTA is hypoplastic and replaced by the FA; Type III-B - the ATA is hypoplastic and the DPA is replaced by the FA; Type III-C - both the ATA and PTA are hypoplastic with the dominant FA [6]. The dominant FA in type III-C variation is also known as the “Peronea Arteria Magna” due to its sole supply to the leg and foot. As the prevalence of the latter anomaly varies between 0.2 and 8.3%, it is important to recognise this variation while harvesting the FA for free flaps, or it may result in limb ischaemia [7].

Among the type III variations, the most common occurrence is type III-A, observed with a prevalence ranging between 1.5% and 11%, and involves a hypoplastic or aplastic PTA with a dominant FA [8]. The type III-B pattern exhibits a varying incidence ranging from 1.6% to 7.1%, wherein the FA substitutes for the DPA in the presence of a hypoplastic ATA [9]. In such instances, the anterior perforating branches of the FA also contribute to the blood supply in those areas [10,11]. The current report aligns with a type III-B variation, even though the ATA was not hypoplastic despite its shortened course. In addition, the blood supply to the extensor compartment was facilitated by the anterior perforating branches of the FA.

During development, the arterial pattern of the lower limb originates from the axial sciatic artery [Table/Fig-2a-c]. In humans, the sciatic artery undergoes regression, with the middle and distal segments persisting to give rise to the popliteal and fibular arteries. During this developmental process, the emerging femoral artery establishes connections with the sciatic artery, ultimately giving rise to the ATA and PTA. The perforating arteries are formed between the ATA and fibular arteries. Thus, the variations in the branching pattern of the popliteal artery can be attributed to the regression or persistence of the axial sciatic artery and its communication with the developing femoral artery [12].



[Table/Fig-2a-c]: a) Development of femoral and axial arteries of the lower limb; (b) Communication between the femoral and axial arteries; (c) Adult arterial pattern with regression of the axial artery.
FA: Femoral artery; AA: Axial artery; PA: Popliteal artery; ATA: Anterior tibial artery; PTA: Posterior tibial artery; FA: Fibular artery; PrBr: Perforating branch; IGA: Inferior gluteal artery; PFA: Profunda femoris artery

Due to variations in its course, the DFN is prone to compression underneath the extensor retinaculum. This compression may lead to motor weakness and sensory impairment in the lower part of the leg and foot [6]. Compression neuropathy of the DFN in the tarsal tunnel was called the “Anterior tarsal tunnel syndrome” by Marinacci AA in 1968 [13]. The relationship between the DPA and DFN in the anterior tarsal tunnel was classified into four types by İkiz ZAA et al., as follows: Type I - DPA was medial to DFN in the tunnel, and mtDFN in the dorsum; Type II - DPA was medial to DFN in the tunnel but lateral to mtDFN; Type III- DPA and DFN cross each other multiple times; Type IV- mtDFN was absent, and DPA was medial to the lateral terminal branch of DFN [14]. Conversely, Ranade AV et al., provided a different classification, designating the looping pattern of the DFN around the DPA in the tarsal tunnel as type IV. While these studies did not specifically address variations in the relationship between the DFN and ATA in the distal part of the leg, the present case shares similarities with the looping pattern described by Ranade AV et al., in the tarsal tunnel [15]. This type IV variant of DFN is susceptible to compression beneath the tendon of the extensor hallucis brevis in the tunnel, leading to motor weakness and impaired sensation in the first interdigital area due to its sensorimotor components [2,15]. In addition, DPA thrombosis could lead to anterior tarsal tunnel syndrome [2].

Compression of the nerve can result from various other factors, such as direct trauma, arterial aneurysms, and persistent mechanical irritations. Decompression of the tarsal tunnel by releasing the inferior extensor retinaculum is the treatment of choice [2]. Similarly, the present report identifies two vulnerable locations for DFN compression. Firstly, in the distal part of the leg, where the nerve crosses the artery posteriorly, and secondly, in the proximal tarsal tunnel; where mtDFN traverses anteriorly across the DPA from the lateral to the medial side.

CONCLUSION(S)

Awareness of these neurovascular variations in the leg and foot is significant for vascular surgeons performing fasciocutaneous flap surgeries or arterial reconstructions in femorotibial bypass graft procedures, as well as for orthopaedic surgeons during surgical clubfoot release. Compression of the DFN in the lower leg may result in “anterior tarsal tunnel syndrome,” and any deviations in its course further heighten the risk of compression.

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