

Flexor Digitorum Accessorius Longus in the Tarsal Tunnel: A Rare Anatomical Variant

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ABSTRACT

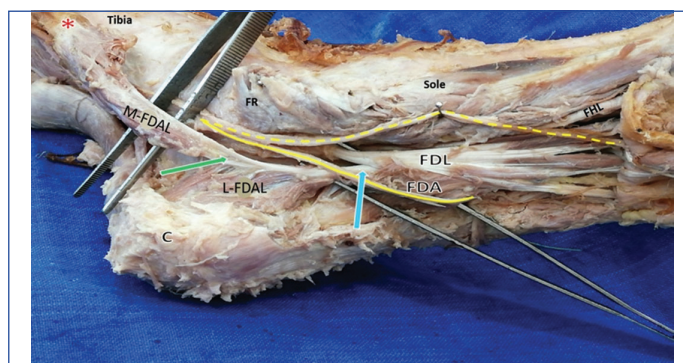
During the routine dissection of an 80-year-old male cadaver, an unusual variant of the Flexor Digitorum Accessorius Longus (FDAL) muscle was identified in the left ankle. The FDAL, with two distinct heads- medial (tibial) and lateral (calcaneal)- was found occupying the tarsal tunnel and partially obscuring the deep flexor tendons and neurovascular structures. This variant crossed over the posterior tibial nerve, which had bifurcated into its medial and lateral plantar branches, contributing to a potential site for compression. The FDAL's rare muscular form in the lower tarsal tunnel and its anatomical positioning suggest a predisposition to Tarsal Tunnel Syndrome (TTS), which may present with pain, paraesthesia, or movement restriction. Magnetic Resonance Imaging (MRI) is essential for accurate diagnosis. This case supports evolutionary and embryological theories of muscle descent and highlights the clinical significance of FDAL in differential diagnosis and surgical planning for TTS. Awareness of such variations is crucial for anatomists, clinicians, and surgeons.

Keywords: Calcaneal head, Flexor retinaculum, Tarsal tunnel syndrome

CASE REPORT

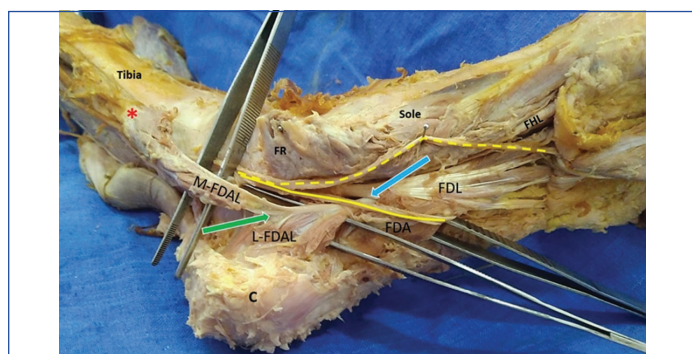
During the dissection of the left ankle of an 80-year-old male cadaver, an unusual muscle belly was identified. The FDAL was found occupying the tarsal tunnel, where it partially concealed the underlying deep flexor tendons and the accompanying neurovascular structures beneath the Flexor Retinaculum (FR). The FDAL had two distinct origins: a medial (proximal or tibial) head and a lateral (distal or calcaneal) head [Table/Fig-1]. The tibial head originated from the lower medial margin of the tibia and extended anteriorly and inferiorly into the tarsal tunnel, where it joined the calcaneal head. Within the tunnel, the tibial portion of the muscle lies deep to the FR and superficial to the deep flexor tendons, posterior tibial artery, and posterior tibial nerve, effectively crossing over the neurovascular bundle. The calcaneal head arose from the inferomedial surface of the calcaneus and coursed forward and medially to merge with the tendon of the tibial head. Anatomically, the tibial head was situated superficially and medially, while the calcaneal head lay superficially on the lateral aspect of the tunnel contents. Notably, the posterior tibial nerve bifurcated within the tarsal tunnel into its medial and lateral plantar branches, which passed between the accessory muscle and the standard flexor tendons.

Inside the tarsal tunnel, it enters as a muscle belly, then both heads get merged and exit as tendons. The blended tendon runs forwards and enters the second layer of the sole, lateral to the tendon of the FDL, distal to the master Knot of Henry (converging point of the FDL and the Flexor Hallucis Longus (FHL) tendons). Then, it gets attached to the tendon of FDL at the junction of the insertion of flexor digitorum accessorius [Table/Fig-2]. Moreover, the lateral plantar nerve from the posterior tibial nerve runs from deep to superficial to the tendon of the FDL after exiting at the FR. The remaining structures of this region and another leg have no other variations that were observed.



[Table/Fig-2]: Distal attachment of the Flexor Digitorum Accessorius Longus (FDAL).

M-FDAL: Medial head of the FDAL; L-FDAL: Lateral head of the FDAL; FDA: Flexor digitorum accessorius; FDL: Flexor digitorum longus; FR: Flexor retinaculum; FHL: Flexor hallucis longus tendon. The green arrow shows the attachment of the medial and lateral head FDAL, and the blue arrow indicates the distal attachment of the FDAL tendon with FDL, Undotted yellow line; Lateral plantar nerve, Dotted yellow line; Medial plantar nerve.



[Table/Fig-1]: Two heads of proximal attachments of the Flexor Digitorum Accessorius Longus (FDAL).

M-FDAL: Medial head of the FDAL; L-FDAL: Lateral head of the FDAL; FDA: Flexor digitorum accessorius; FDL: Flexor digitorum longus; FR: Flexor Retinaculum; FHL: Flexor Hallucis Longus tendon. Red star indicates the proximal attachment of the medial head; Green arrow shows the attachment of the medial and lateral head FDAL, Blue arrow indicates the distal attachment of the FDAL tendon with FDL, Undotted yellow line; Lateral plantar nerve, Dotted yellow line; Medial plantar nerve.

DISCUSSION

In the ankle region, accessory muscle incidence is common; those are the peroneus quartus (most common), the FDAL, the tibio calcaneus internus, the peroneocalcaneus internus, and the accessory soleus [1]. The FDAL is the second most common accessory muscle present in the ankle region, in approximately 4% to 8% [1,2]. The various origins of the single or double head of FDAL were observed in previous studies from the tibia, fibula, or intermuscular septa of the lower leg. The diagnosis of FDAL-induced TTS can be challenging, as symptoms often mimic other conditions such as plantar fasciitis

Study	Number of heads	Origin	Insertion	Relation to FHL	Appearance in the tarsal tunnel
Bowers CA et al., [1]	Single head	The posterior crural fascia and the proximal portion of the Flexor Digitorum Longus (FDL)	FDL tendon	Posterior to Flexor Hallucis Longus (FHL)	Bulky muscle belly
Hwang SH and Hill RV [10]	Two head- Medial	Inferior margin of the medial malleolus	FDL tendon	Posterior to FHL	Tendinous
	Lateral	Inferior margin of the lateral malleolus			
Athavale SA et al., [11]	Two head - Medial	Medial surface of the calcaneum	The deep surface of the FDL tendon.	Posterior to FHL	Bulky muscle belly
	Lateral	The lateral tuberosity of the calcaneus and the adjoining part of the long plantar ligament.			
Al-Himdani S et al., [12]	Single head	Either from the medial margin of the tibia or the flexor tendon retinaculum or the lateral fibula	Quadratus plantae or the FDL tendon	Posterior to FHL	Bulky muscle belly
Hur MS et al., [9]	Two heads - Medial	The intermuscular septum of the distal leg	Medial border of the medial head of the flexor digitorum accessorius muscle	Posterior to FHL	Both tendinous and muscle belly
		The inner surface of the Flexor Retinaculum (FR)			
Cheung Y, [8]	Variable	Arise from any structure in the posterior compartment	Flexor digitorum accessorius muscle and Flexor Digitorum Longus (FDL) tendon	Posterior to FHL	Bulky muscle belly
Current study	Two heads- Medial or long	The lower part of the medial margin of the tibia	Tendon of the Flexor Digitorum Longus (FDL)	Posterior to FHL	Bulky muscle belly
	Lateral or short head	The lower part of the medial surface of the calcaneum			

[Table/Fig-3]: Variations of Flexor Digitorum Accessorius longus (FDAL) in previous studies [1,8-12].

or peripheral neuropathy. Magnetic Resonance Imaging (MRI) has emerged as the gold standard for identifying the FDAL and its relationship to the tibial nerve, while electrodiagnostic studies may provide additional evidence of nerve compression [3,4]. The knowledge of the locations of these accessory muscles in the ankle was of immense significance during the foot and ankle surgery.

In the upper tarsal tunnel or tibiotalar portion, the FDAL was located between the FR and the neurovascular bundle, the FHL. The posterior tibial nerve was divided into the medial and lateral plantar nerves, and the FDAL was related to the lateral plantar nerve. At the tibioacaneal or lower tarsal tunnel region, the FDAL muscle was found, descending in a tapered form, positioned medially to the FHL and lying deep to the lateral plantar nerve. This tapering structure is typically tendinous or aponeurotic, with a muscular form being uncommon [3]. In our observation, the muscle at this level also followed this pattern, presenting as a rare muscular variant. The posterior tibial nerve is split into the medial and lateral plantar nerves in the lower tarsal tunnel. When it is entrapped and compressed between the medial malleolus and the FDAL muscle, it causes the TTS [5-7]. Accessory muscle entrapment neuropathy accounted for 16.3% of TTS cases, with the FDAL specifically responsible in 12.2% of these instances [6]. Cheung Y study found that the FDAL causes TTS in 12% of cases. It also resembles flexor hallucis syndrome because its mass impact within the tarsal tunnel causes a tethering effect to the flexor tendon, leading to acute pain with limited dorsiflexion of the foot and toes [8].

The previous study by Hur MS et al., observed that 2.5% of cases (2/80 limbs) had two heads of origin of FDAL, in which one head originated from the distal third of the Transverse Intermuscular Septum (TIM) of the distal leg and the opposite head from the inner surface of the FR [9]. According to the origin of the FDAL and its relationship, Hur MS et al., categorised it into three types. Type-1a became its origin from the distal third of the TIM of the leg without crossing the tibial neurovascular bundle. If it is crossing these bundles, it comes under type-1b. In type 2, its origin is from the inner surface of the FR [9]. However, our study shows that the origin of the medial head of FDAL comes under type-1b, and the lateral head was unique in its origin when compared with the Hur MS et al., study. [Table/Fig-3] shows variations of FDAL in previous studies [1,8-12].

Evolution and embryological basis: A few theories are needed to explain the evolution of this muscle. One theory explains that the muscle group runs down from the leg into the sole, wherein the medial and lateral heads of the FDAL represent the successive stages of the descent of the Flexor digitorum longus muscle [13]. Another theory described that the medial head was developmentally derived from the deep head of flexor digitorum brevis or FHL. The lateral head was homologous to the flexor digitorum accessorius of other mammals [11]. This study also follows the above theory for these anomalous muscles.

The TTS manifests as numbness, pain, paresthesia, burning sensation, and limitation of movements in the foot's sole. It occurs due to accessory muscles, trauma, infection, perineural fibrosis, oedema, space-occupying lesions, or compartment syndrome [7]. These symptoms will get aggravated during exercise or walking and relieved during rest. It can be treated by the release of the tendon, debulking, excision, or fasciotomy [12]. The presence of the muscle and its relationship to surrounding structures can be determined via MRI, which aids in precise diagnosis and treatment planning. Clinicians should take the FDAL into account when making a differential diagnosis of TTS because of the growing recognition of auxiliary muscles in foot and ankle disease. Future studies should concentrate on enhancing diagnostic imaging methods and investigating possible non-surgical treatment approaches for situations in which the FDAL muscle causes nerve compression [5].

CONCLUSION(S)

Understanding the intricate structure of the FDAL and how it relates to the tarsal tunnel will help determine how TTS is caused. This case highlights how crucial it is for healthcare providers to comprehend the structural variations of FDAL and how they could affect TTS. Better imaging techniques and a thorough understanding of this muscle can help diagnose and effectively treat TTS caused by the FDAL.

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