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Revisiting of the fibularis brevis muscle tendon classification according to attachment sites

Gülden Kayan[1], Alev Bobuş Örs[1], Turan Koç[2]

[1]*Department of Anatomy, Faculty of Medicine, Mersin University, Mersin, Türkiye*
[2]*Department of Anatomy, Faculty of Medicine, Kahramanmaraş Sütçü İmam University, Kahramanmaraş, Türkiye*

Abstract

Objectives: Variations and displacements in the attachment sites of the fibularis brevis tendon (FBT) are clinically significant, particularly due to the mechanical forces they exert on the fifth metatarsal bone and their potential role in fracture mechanisms involving this structure. This study aimed to investigate the anatomical characteristics of the fibularis brevis tendon attachment sites, its possible intertendinous connections with neighboring muscles, and its potential influence on fracture patterns at its bony insertion.

Methods: A total of 27 embalmed lower extremities (15 males, 12 females; mean age: 69.48±14.39 years) from the Anatomy Department of Mersin University were dissected. The FBT was classified based on its attachments to surrounding tendons and bones.

Results: The FBT was observed to attach to the medial cuneiform, the fifth metatarsal bone, and the proximal phalanx in various combinations. Specimens showing a low-lying muscle belly (n=2) were excluded from the main classification. Based on the attachment patterns, a single tendon slip was found in 52% of cases (n=13), while multiple tendon slips were observed in 48% (n=12) of specimens, two slips in 24% (n=6), three slips in 16% (n=4), and four slips in 8% (n=2).

Conclusion: Knowledge of the anatomical variations in the attachment patterns of the FBT can provide valuable insights into the extent and localization of fractures at the tendon's insertion site. Understanding these variations may also assist in surgical planning and interventions involving the FBT or the lateral aspect of the forefoot, particularly in cases of dislocation or trauma.

Keywords: cadaver; fibularis brevis muscle; variation

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Introduction

The fibularis brevis muscle (FBM) and its longer counterpart, the fibularis longus muscle (FLM), form the lateral aspect of the leg.[1,2] Specifically, the FBM causes eversion, i.e. internal rotation (pronation) of the foot.[2,3] The FBM originates from the lower two-thirds of the lateral aspect of the fibula and usually inserts into the proximal aspect of the fifth metatarsal bone (V.MT). Although injury of it solely in lateral ankle sprain is frequent, injury of it together with the tendon of the FLM is more frequent.[4]

It is known that intense contraction of the lateral region muscles and sudden and violent movements of the extremities can lead to avulsion fractures at the attachment points of the tendons. Avulsion fractures of the V.MT base are among the most common fractures encountered in orthopedic clinics.[5,6] Ankle and foot injuries are common during routine physical activities, amateur and professional sports activities.[7] Chronic pain is reported by 50% to 79% of individuals with ankle sprains for up to 6 years after the injury. This situation significantly increases the burden on health and quality of life.[8] It has been suggested that being aware of several common pathologies related to the peroneus brevis muscle and tendon like tendon sprains, dislocations or separations can help in the diagnosis of foot and ankle injuries.[9] When a tear occurs in FBM during lateral ankle sprain permanent swelling can occur in the sheath of the fibularis brevis tendon (FBT) and at the lateral

part of the ankle. Similarly, supination-adduction injuries in the ankle can also cause damage of the FBT and the lateral ligaments of the ankle. In addition to all clinical conditions, it has been reported that the FBT can pull and dislocate the V.MT at the metaphyseal-diaphyseal junction when the Jones fracture occurs.[10] Different configurations of ruptures or oblique/spiral type fractures can occur in the V.MT.

Conservative treatments are generally sufficient for injuries in FBT, but in chronic cases and for highly active individuals, surgeries to reattach or reconstruct the tendon are necessary. Depending on the degree of injury and damage to the FBT, different repair techniques (deepening of the retro-malleolar groove, tendon grafting or rerouting procedures, etc.) can be applied.[11] Knowing the FBT variations is also important because of their role in discomfort and disability around the ankle.[12] Nowadays, management of chronic Achilles tendon tears with a less invasive procedure using FBT is often preferred.[13]

The aim of our study is to classify the types of FBT attachment sites in cadavers and to provide detailed anatomical information on the variability of FBT attachment patterns. This knowledge may inform surgical practices involving V.MT fractures and procedures in the lateral foot region.

Materials and Methods

The study was conducted on 27 lower extremities (15 males, 12 females; mean age: 69.48±14.39 years) fixed in 10% formalin, obtained from the inventory of the Department of Anatomy, Faculty of Medicine, Mersin University. Dissections were performed on the lateral aspects of the leg and foot, with the full course of the FBT documented throughout.

With the specimens in anatomical position, dissection lines were marked on the lateral midfoot, lateral ankle, dorsum, and lateral foot (**Figure 1**). A transverse skin incision was made approximately 10–15 cm proximal to the lateral malleolus on the distal lateral leg, and dissection of the skin and superficial fascia was initiated. The incision was extended distally toward the ankle. After exposing the lateral malleolus (LM), the deep fascia and peroneal retinaculum were dissected (**Figure 1**), allowing exposure of the FLM, FBM, and the tendons within the peroneal compartment (**Figure 1**). The FBT and FLT were then followed along their course behind and distal to the LM.

The dorsal fascia of the foot was dissected to expose the distal tendon insertions. Surrounding connective tissues and fascia at bony landmarks were cleaned, and the fifth metatarsal (V.MT), cuboid bone, proximal phalanges (PP), and fibularis digiti quinti (also referred to as fibularis tertius, FDQ), if present, were identified and documented (**Figure 1**).

The classification of the FBT was carried out based on two main criteria: the number of tendon slips and their anatomical attachment sites. The primary classification was determined by the number of slips observed, and each main type was designated using Roman numerals (Type I, II, III, etc.). For instance, if the FBT consisted of a single slip, it was classified as Type I; if it had two slips, it was classified as Type II, and so forth.

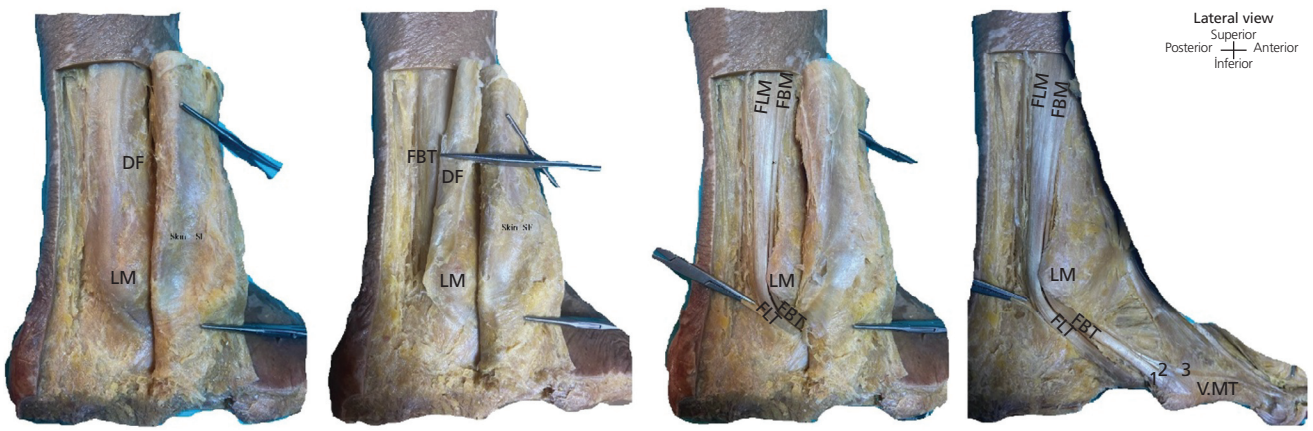


Figure 1. Dissection steps of fibularis brevis tendon (FBT), lateral view of the right foot. **1–3:** slips of FBT; **DF:** deep fascia; **FBM:** fibularis brevis muscle; **FBT:** fibularis brevis tendon; **FLM:** fibularis longus muscle, **FLT:** fibularis longus tendon; **LM:** lateral malleolus; **V.MT:** first metatarsal bone.

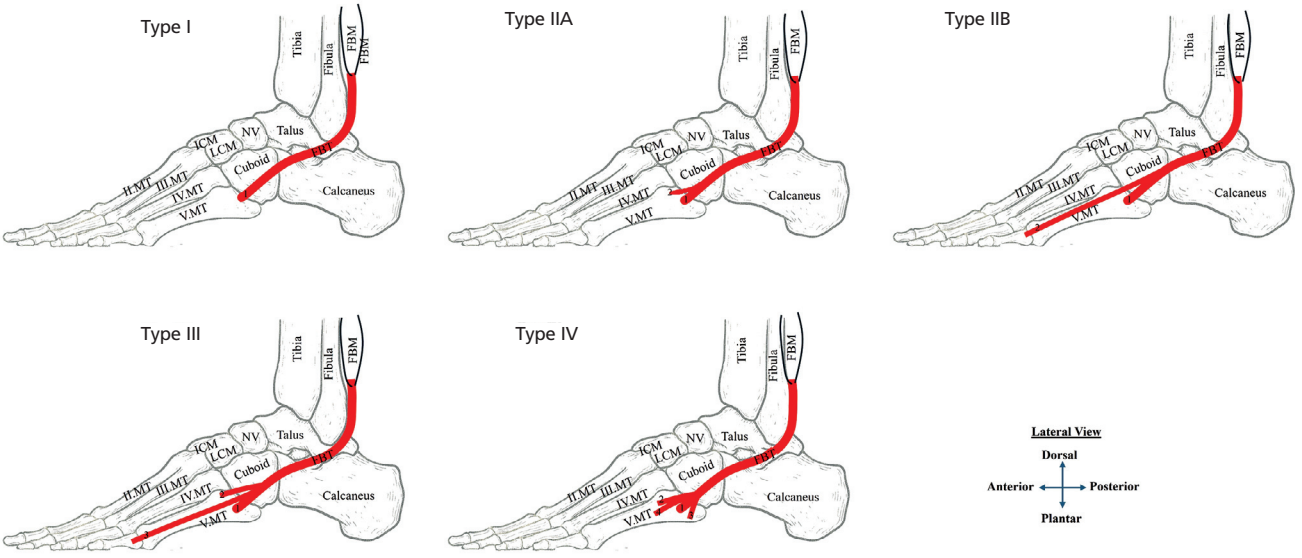


Figure 2. Schematic drawing of the classification of the FBT according to their slips and attachment sites; lateral view of the right foot. **1–4:** slips of FBT; **FBM:** fibularis brevis muscle; **FBT:** fibularis brevis tendon; **IMC:** intermediate cuneiform bone; **I-V.MT:** metatarsal bones; **LCM:** lateral cuneiform bone; **LM:** lateral malleolus; **NV:** navicular bone.

In addition to the main types, subtypes were defined according to the specific bony structures to which the tendon slips were attached. These subtypes were denoted by capital letters (A, B, C, etc.). For example, if the FBT attached solely to the V.MT, it was designated as Subtype A. If the tendon inserted exclusively into the PP, it was classified as Subtype B. This dual classification system allowed for a detailed and systematic evaluation of the morphological variations in FBT insertion patterns.

Results

During the dissections, a low-lying muscle belly was identified in two feet. These specimens were excluded from the classification due to their anatomical variation. Therefore, the main classification based on the number of tendon slips and their attachment sites was performed on 25 feet. The FBT was observed to have between one and four slips (**Figure 2**). It was found to attach to the medial cuneiform bone (MC), the V.MT, and the PP in various combinations (**Figure 2** and **Table 1**). A single FBT slip was observed in 52% of cases (n=13) (**Figure 3a**), while multiple slips were identified in 48% (n=12) (**Table 1**). Among the multiple-slip cases, two slips were found in 24% (n=6) (**Figures 3b** and **3c**), three slips in 16% (n=4) (**Figure 3d**), and four slips in 8% (n=2) (**Figure 3e**).

Discussion

In the literature, morphological variations are often interpreted from an evolutionary perspective. According to this view, muscles such as the plantaris or palmaris longus may gradually become rudimentary,[14–17] while

Table 1
Classification of FBTs according to their slips and attachment sites.

Types	Subtypes	Attachment sites & configurations	n (%)	Total n (%)
Type I	-	Base of V.MT	13 (52%)	13 (52%)
Type II	Type IIA	Base of V.MTx2 Slips	3 (12%)	6 (24%)
	Type IIB	Base of V.MT and FDQ	3 (12%)	
Type III	-	Base of V.MTx2 Slips and FDQ	4 (16%)	4 (16%)
Type IV	-	Base of V.MTx2 Slips and body of V.MTx2 Slips	2 (8%)	2 (8%)

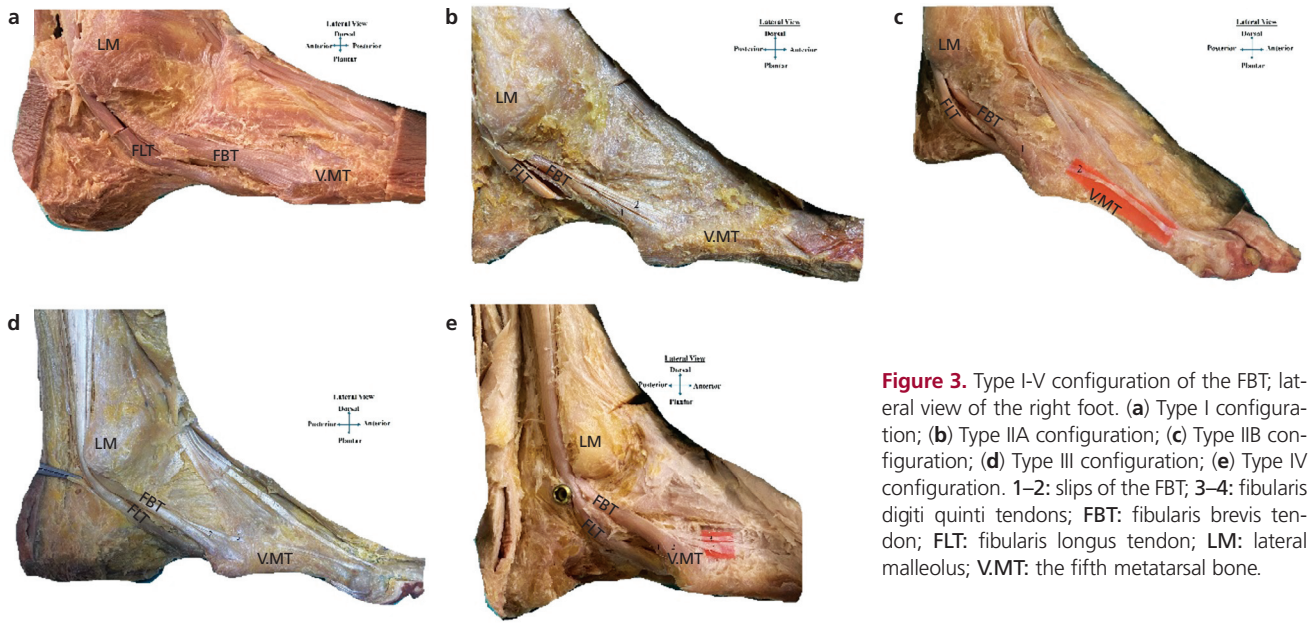


Figure 3. Type I-V configuration of the FBT; lateral view of the right foot. (**a**) Type I configuration; (**b**) Type IIA configuration; (**c**) Type IIB configuration; (**d**) Type III configuration; (**e**) Type IV configuration. **1–2:** slips of the FBT; **3–4:** fibularis digiti quinti tendons; **FBT:** fibularis brevis tendon; **FLT:** fibularis longus tendon; **LM:** lateral malleolus; **V.MT:** the fifth metatarsal bone.

the others such as the fibularis tertius may become hypertrophic or more prominent over successive generations.[18] Furthermore, it has been suggested that morphological variations in origin or insertion patterns may indicate that these structures have not yet reached their final stage of evolutionary development.[19] The FBM is known to display a variety of insertion types and may exhibit accessory bands.[20–24] In certain cases, an accessory band may arise from the FBT and typically insert onto the proximal or middle phalanx of the little finger, a feature that has been associated with the evolutionary tendency toward the development of the FDQ, a muscle present in some primates.[25] Additionally, the FBT may send a gliding slip to the abductor digiti minimi or form a gliding connection with the FLT.[20] Bhargava et al.[23] reported that the FBT may insert at various locations, including the head of the V.MT, cuboid bone, calcaneus, the fourth metatarsal bone, the posterior tibio-fibular ligament, and even the middle and distal phalanx of the fifth toe. Anson[22] similarly documented insertions at the cuboid, head of the fifth metatarsal, fourth metatarsal, and both the middle and distal phalanges of the fifth toe. Musiał[26] classified four types of distal FBT insertion. The most common type involved insertion onto the tuberosity of the fifth metatarsal. A frequent variant included an additional slip inserting into the dorsal fascia of the foot at the level of the fourth interosseous space. The third most common variant involved an additional slip inserting into the extensor aponeurosis of the fifth toe, while the rarest configuration–termed the trifurcate type–showed three slips inserting onto the tuberosity of the fifth metatarsal, the extensor aponeurosis of the fifth toe, and the dorsal fascia at the level of the fourth interosseous space. In our study, we observed that the FBT may exhibit between one and four slips. A single slip was the most commonly encountered configuration, while four slips represented the rarest. Importantly, regardless of the number of slips, all cases showed insertion onto the base of the fifth metatarsal.

The prevalence of FDQ is not known exactly and its incidence in the literature is reported to vary between 15.5% and 59.7% depending on the studies.[20,22,27–31] In our current study, FDQ was found in 28% (n=7) of the cases and we found that it was within the incidence range reported in the literature. One of the most frequently observed cases among the muscle-tendon variations in the peroneal region is the fibularis quartus muscle (FQ) and its frequency has been reported to be between 5% and 20%.[32,33] It has been reported that this observed variation may be typically asymptomatic, but it may also be associated with increased susceptibility to FBT ruptures or tears along with compression in retromalleolar groove and therefore ankle pain.[34] In cases where FQ is present, it is frequently reported that it may originate from the fibers of the FBM and is located in the retrotrochlear height of the calcaneus.[32] We did not

encounter any FQ cases in our study. Another known variation in the FBM anatomy is the low-lying muscle belly, defined as the muscle belly, approximately 2 cm above the distal fibular end of the FBM, beyond the expected end of the muscle belly.[35] This rare phenomenon has been suggested as a causal factor in FBT rupture and subluxation.[36] Although it is difficult to establish a direct causal relationship, one study found that 80% of patients with prior FBT rupture and 9 out of 10 patients who had FBT subluxation during ankle surgery had a low-lying FBM belly.[35] In our study, we encountered low-lying muscle belly in 2 feet. However, we excluded these 2 feet from the classification in terms of their insertion sites.

Imre et al.[37] defined 3 types by classifying according to the number of tendons and reported single tendon as 59.5%, double slip as 28.6% and trifurcate as 11.5%, respectively. Olewnik et al.[38] defined two main types according to single and double slip (70.6% and 29.4%, respectively). They suggested a separate definition for FDQ going to the 5th finger. In our study, we determined that the FDQ definition remained within the classification in accordance with Imre et al.[37] considering it as an extension of FBT. Additionally, the most frequently observed type was single slip (52%), and we found that it was compatible with the literature. In our classification study, we combined the suggestions of both Imre et al.[37] and Olewnik et al.[38] and made the main classifications according to the attachment site, then the number of tendon slips and the presence of FDQ. In our study, we encountered low muscle belly in 2 feet. We excluded 2 feet from the classification for standardization. It is not clearly stated in the literature[37,38] whether they include low muscle belly cases in the classification.

It has been reported that FBM and FLM play important role in stabilizing the ankle in the lateral direction and that rupture or separation of both of them may be associated with lateral ankle functional instability and that FBM tears in particular may be more common.[39–41] Tears are believed to be produced by the wedge-like compressive forces of FLT against FMT in foot dorsiflexion.[40] Imre et al.[37] support the hypothesis that narrowly placed tendons may impose greater stress on the insertion area because the internal force per unit area will be increased compared to a wider insertion area. In addition, they suggested that this may be a general assumption and that further biomechanical studies are needed to establish its true validity in biological tissues. In this context, an important question arises as to whether one of the FBT types may specifically affect the frequency of FBM tears.

Conclusion

In cases of persistent lateral ankle pain–particularly those associated with complications arising from accessory bands of the fibularis brevis muscle (FBM)–an understanding of the morphological variations and insertion patterns of the FBM and its tendon is clinically valuable. Given that FBM grafts are frequently utilized in reconstructive procedures, awareness of the potential for multiple tendon insertions is also important for surgical planning. Furthermore, knowledge of these anatomical variations can contribute to safer and more effective surgical interventions involving the lateral aspect of the forefoot.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

GK: project development, dissections, manuscript writing and editing; ABÖ: dissections and manuscript editing; TK: project development, dissections, manuscript writing and editing, supervision.

Ethics Approval

The study was approved by the Mersin University Clinical Research Ethics Committee (Approval numbers: 2023/665).

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ORCID ID:
G. Kayan 0000-0002-0042-8803;
A. Bobuş Örs 0000-0003-4026-5460;
T. Koç 0000-0001-6970-3351

Correspondence to: Turan Koç, PhD
Department of Anatomy, Faculty of Medicine,
Kahramanmaraş Sütçü İmam University, Kahramanmaraş, Türkiye
Phone: +90 344 300 26 94
e-mail: turankoc@ksu.edu.tr

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