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Case Report

Absence of the fourth tendon of flexor digitorum brevis in the right foot of a male cadaver: A case report with clinical implications

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Abstract

The Flexor digitorum brevis (FDB) muscle of the plantar aspect of the foot typically forms four tendons that insert into the lateral four toes. Although variations in tendon number and insertion patterns are common (13-83% worldwide), they are critically understudied with respect to biomechanical implications, especially in populations with high prevalence for variation (77.3% in South Asians). The present case report describes the unilateral absence of the fourth FDB tendon of a 60-year-old male cadaver of South Asian origin using comprehensive morphometric analysis using digital callipers: muscle belly length measured 82.20 mm and widths varied (proximal: 9.10 mm, midpoint: 11.4 mm, distal: 5.92 mm); the remaining three tendons measured 79.09 mm, 65.24 mm, and 56.77 mm. This quantitative documentation adds to limited morphometric data available for South Asian populations and provides population-specific reference values crucial to surgical planning as well as demonstrating a need for biomechanical analysis and standardized clinical assessment protocols in high-variation populations.

Keywords: Anatomic variation, Foot anatomy, Muscle, Skeletal anatomy, Tendon transfer, Biomechanical phenomena.

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1. Introduction

The Flexor digitorum brevis (FDB) is an important muscle of the plantar foot that originates from the calcaneus and plantar aponeurosis to insert via four tendons onto the middle phalanges of the lateral four digits, 1-3 which can assist in toe flexion, longitudinal arch maintenance, and elastic energy storage for locomotion.4,5 Biomechanical studies have shown that FDB is a mixed fiber type (43.9% Type IIa, 51.6% Type IIx, 4.4% Type I) muscle that can produce force while also being fatigue resistant to accommodate the demands of prolonged weight-bearing activities.[6]

Anatomical variations in the FDB are extremely common across populations, and the absence of the fourth tendon is the most frequent variant.[7] The prevalence rates have been reported to range from 13% to 83% based on recent systematic reviews and meta-analyses.[8] There is a significant clustering by ethnicity: South Asian populations show the highest rates (100% in Nepalese), whereas European populations have rates around 20%.[9] These population differences reflect phylogenetic degeneration at different evolutionary stages.[10]

However, there are still research gaps: most recent literature (2020-2025) is purely descriptive, and there has been no biomechanical analysis of the loss of tendon on ground reaction forces, plantar pressure distribution, or compensatory muscle activation patterns.[11,12] No standardized clinical assessment protocols exist for evaluating FDB variations that are a significant limitation for surgical planning and rehabilitation strategies.[13]

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Beyond anatomical curiosity, FDB variations have clinical implications in tendon transfer procedures for correction of claw toes, surgical approaches for tarsal tunnel decompression, and may play a role in changes to foot biomechanics that can lead to metatarsalgia or plantar fasciitis.[14,15] More advanced imaging techniques such as high-resolution ultrasound with sonoelastography and synchrotron radiation micro-tomography now allow us to visualize these variations, but standardized protocols are lacking.[16]

Here we report a detailed morphometric analysis of an absent fourth FDB tendon in a South Asian individual, which is critically important for quantitative documentation in the population with the highest global prevalence of this variation. Such data are necessary to develop targeted surgical approaches and clinical protocols for populations most affected by these anatomical variations.

2. Case Report

In routine dissection for undergraduate anatomy education, we observed that there were no identifiable fourth tendon of the flexor digitorum brevis in the right foot of a South Asian male cadaver (approximate age 60 years) with no evidence of previous foot surgery, trauma, or congenital abnormalities. This ethnic identification is particularly relevant as South Asian populations are known to have high prevalence for FDB variations.

Standard anatomical techniques were used for the dissection of the plantar region. Following removal of skin and superficial fascia, the plantar aponeurosis was reflected to expose the first layer of plantar muscles. The FDB muscle originated from the medial process of the calcaneal tuberosity, immediately deep to the plantar aponeurosis (**Figure 1**, **Figure 2**). Interestingly, only three tendons emerged from the muscle belly, with no tendons in the fifth toe.

All measurements were obtained using a non-expansile thread to measure the muscle and then precision digital callipers (Mitutoyo 500-196-30, accuracy ±0.01 mm) to measure the thread. Three independent measurements were taken for each parameter and were then averaged:

2.1. Muscle belly dimensions

1. Total length: 82.20 ± 0.15 mm
2. Proximal width: 9.10 ± 0.12 mm
3. Mid-belly width: 11.40 ± 0.18 mm
4. Distal width: 5.92 ± 0.10 mm
5. Maximum thickness: 7.82 ± 0.14 mm

2.2. Tendon measurements

1. First tendon (to second toe): 79.09 ± 0.21 mm
2. Second tendon (to third toe): 65.24 ± 0.19 mm
3. Third tendon (to fourth toe): 56.77 ± 0.16 mm
4. Fourth tendon (to fifth toe): Absent

The flexor hallucis longus tendon and flexor hallucis brevis muscle formed the medial border (FDB), while the flexor digiti minimi brevis and abductor digiti minimi muscles formed the lateral border (FDB). The branches of the medial plantar nerve crossed superficial to the tendons of FDB as they emerged from the belly. All four present tendons exhibited normal bifurcation patterns at their insertion onto the proximal phalanges, permitting passage of the flexor digitorum longus tendons.

The contralateral foot showed normal four-tendon configuration, confirming the unilateral nature of this variation. No compensatory hypertrophy was observed in adjacent muscles, though this assessment was limited by the cadaveric state.

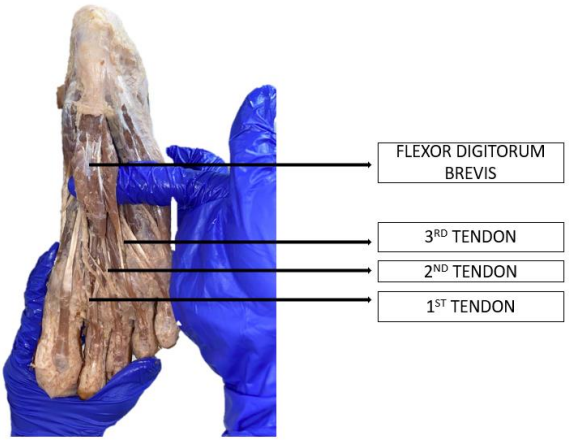

Figure 1: Photograph showing the absence of fourth tendon of flexor digitorum brevis to the fifth toe

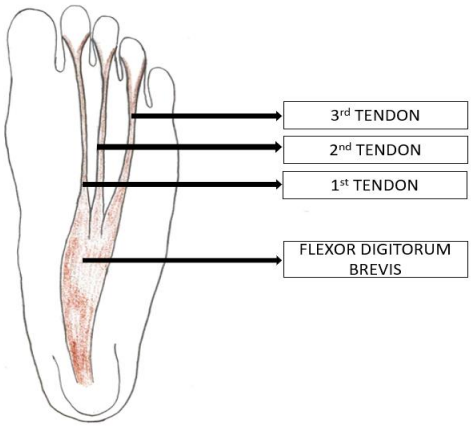

Figure 2: Schematic diagram showing the absence of fourth tendon of flexor digitorum brevis

3. Discussion

The documented absence of the fourth FDB tendon in this South Asian cadaver exemplifies a clinically significant anatomical variation that contributes valuable population-specific morphometric data to the existing literature. This case is particularly relevant given that South Asian populations demonstrate the highest global prevalence of FDB variations.[11,16]

3.1. Population-specific prevalence and evolutionary significance

It is interesting that lack of the fourth FDB tendon shows strong ethnic clustering, with South Asian populations having the highest worldwide incidence at 77.3%.[8] There are also regional differences within this population: Northern Tamil Nadu populations had 83.3%, while Nepalese cohorts exhibited 100% absence of the FDB to the fifth toe.[9,17] This is in contrast to ~20% in European populations and intermediate rates among Hispanic populations (40% in Puerto Ricans).[17]

This morphometric data from a South Asian cadaver supplies important population-specific reference values: the dimensions of the muscle belly (82.20 mm long by 11.40 mm wide) and the gradual reduction in length of the tendons (79.09 mm, 65.24 mm, 56.77 mm). These measurements are needed to create population-specific surgical approaches and imaging protocols, especially considering how common this variation is in South Asian patients.[18]

The high prevalence in South Asian populations suggests evolutionary adaptation patterns unique to this geographic region. This phylogenetic degeneration may reflect specific biomechanical adaptations to environmental or lifestyle factors, warranting further investigation into the functional implications of these variations.[10]

3.2. Biomechanical implications

Although there has been extensive documentation of FDB variations, biomechanical implications are largely theoretical. During the stance phase of gait, the mixed fibre composition of the FDB contributes to elastic energy storage.[6] This allows for both quick force production and sustained contraction. The absence of the fourth tendon theoretically decreases lateral foot stability and can increase demands on the flexor digitorum longus and intrinsic foot muscles.[19]

Recent advances in motion analysis and plantar pressure mapping offer unprecedented opportunities to quantify these biomechanical alterations. However, no studies have systematically compared gait patterns, ground reaction forces, or muscle activation patterns between individuals with and without FDB variations.[20] This represents a critical knowledge gap affecting clinical decision-making.

3.3. Clinical Correlations

FDB variations have been associated in novel clinical correlations linking them to specific pathological conditions; recent case reports document associations with tarsal tunnel syndrome, where accessory muscles or altered anatomy can contribute to nerve compression.[21] The lack of the fourth FDB tendon might paradoxically decrease crowding within the tarsal tunnel and requires systematic investigation. Surgical implications go beyond anatomical awareness: tendon transfer procedures for claw toe correction depend on availability of FDB tendons, with absent tendons requiring alternative donor sites.[22] The variation also impacts approaches to plantar fasciotomy and neuroma excision, where altered anatomy can increase risk of iatrogenic injury.[23]

3.4. Advanced imaging

Recent advances in imaging technologies now allow unprecedented visualisation of FDB variations. The high-resolution ultrasound with sonoelastography can dynamically assess FDBs, whereas synchrotron radiation micro-tomography has sub-micrometric resolution to image individual fibres.[16,24] Nevertheless, the lack of standardisation of these protocols hampers comparative analysis among studies. The morphometric data provided here, which were obtained using a non-expansile thread and precision digital callipers, provide a quantitative baseline for future comparisons. The gradual diminution in tendon lengths (79.09 mm, 65.24 mm, 56.77 mm) corresponds to normal anatomical proportions, whereas the muscle belly dimensions provide reference values for imaging studies.

4. Limitations and Future Directions

The main limitation to this case report is the lack of biomechanical testing due to the cadaveric nature of the specimen, but it has the advantage of providing morphometric data that are specific to a South Asian population which has the highest prevalence globally for variations of FDB. Future studies should include dynamic imaging and functional assessment, electromyographic analysis of compensatory patterns and comparison between different South Asian subpopulations in live patients; and development of population-specific standardised assessment protocols remains paramount for advancing clinical applications in regions with high variation in prevalence.

5. Conclusion

In this South Asian cadaver, absence of the fourth FDB tendon is an important morphometric finding in the most prevalent ethnic group worldwide (77.3% in South Asians), which goes beyond simple descriptive anatomy to provide reference values that will be useful for surgical planning in these populations. This combination of high population prevalence, significant clinical implications, and critical knowledge gaps in foot biomechanics highlights the need for population-specific research approaches as surgical techniques advance and imaging capabilities improve, along with the development of evidence-based, population-specific guidelines for clinical assessment and surgical planning, especially for South Asian patients who are disproportionately affected by these anatomical variations.

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7. Conflict of Interest

None.

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10. Conflict of Interest

None.

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