Morphology of flexor digitorum brevis muscle in northern Tamil Nadu region: an anatomical study with phylogenetic perspective

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Abstract

Background and aims: “Arches of foot” formed by the combination of skeletal and a muscular element is a unique feature of evolution as an adaptation to habitual erect posture in humans. Flexor digitorum brevis (FDB) is the most superficial intrinsic muscle of the sole that present with variations frequently. The objective of this study was to find out the pattern of presentation of FDB in northern Tamil Nadu region. Material and methods: Thirty soles of 12 male and three female embalmed cadavers were dissected and FDB was observed for variations. A comparative analysis was done with previous studies. Results: Twenty five soles showed absence of FDB tendon to little toe. Three soles confirmed to the classical book description. The soles of 62 years old male cadaver presented with a variation of FDB. It showed a separate deep slip to the 5th toe arising from intermuscular septum and from long flexor tendon with the slip found to get inserted at the base of middle phalanx bilaterally. The incidence of 83.3% absence of FDB tendon to 5th toe in the present study was significantly higher when compared to many previous reports. Conclusion: Variations of FDB are clinically significant because FDB musculocutaneos flap is used in the reconstruction of the heel pad and FDB tendons are used in tendon transfer surgeries for claw or hammer toe deformities. The absence of FDB tendon to the 5th toe shows clustering around Asian region, which signifies possibility of occurrence of evolutionary changes in specific topographic region.

Key words: flexor digitorum brevis, human foot, variation, 5th toe tendon, evolutionary change.

Introduction

Plantigrade bipedalism is an unique feature of human evolution. With the transformation to the erect posture, the architecture of foot has undergone suitable changes compared to the apes. The human foot is conferred mechanical complexity and structural stability due “arches of foot” which are maintained by skeletal and muscular elements.

Among the muscular elements, the flexor digitorum brevis is the most superficial intrinsic muscle of the sole of foot, located deep to plantar aponeurosis. It arises from the proximal part of plantar aponeurosis, from the medial process of tuber calcanei and the two intermuscular septi that separate it from adjacent muscles. Its four tendons proceed towards lateral four toes in the four digital tendon sheaths. Within the sheath, the tendon of FDB splits at the base of proximal phalanx to allow the long flexor tendon to pass to distal phalanx. The split tendon inserts into the sides of the middle Phalanx. Main action of FDB is flexion of the toes and its paralysis leads to distortion of arches of foot. The evolutionary adaptation to an erect posture led to changes in the architecture of foot. One such change is seen in case of little toe, which has lost its function of opposition, in comparison to lower world mammals.

Variations in presentation of FDB were reported as early as 1816. Most commonly reported variations of FDB being: (a) the tendon to 5th toe arising as a separate muscle, (b) having an additional deep origin from flexor digitorum longus or intermuscular septum, (c) presence of supernumerary slips. Absence of tendon to the
5th toe has also been infrequently reported with a wide range from 6.7%-100% by various authors 3,5,9,10.

Because of its clinical importance in preparing musculocutaneous flap in heel pad reconstruction surgeries, tendon transfer for claw/hammer toe deformities 10,11,12 and because of inadequate literature in the Indian context, the present study of pattern of presentation of FDB in Northern Tamil Nadu region was undertaken.

Materials and methods

Thirty intact soles in 15 embalmed cadavers were dissected in the Institute of Anatomy, Madras Medical college, Chennai, during routine undergraduate course. Three of the cadavers were females and the remaining 12 were males. All were of individuals between 25-70 years of age without any gross foot deformity. The dissected soles were examined in detail for pattern of presentation of flexor digitorum brevis muscle. A comparative analysis was done with the previous studies.

Result

Of the 30 soles studied, 24 soles presented with absence of FDB tendon to the little toe. The soles of only one cadaver had tendon to 5th toe as per classical book description. In one cadaver, the left sole presented a typical pattern and right sole showed absence of tendon to 5th toe.

In a male cadaver aged 62 years, a varied pattern of presentation of FDB tendon to the 5th toe was observed. On the right sole the main FDB was found to divide into only three slips, i.e to 2nd, 3rd and 4th toes. A separate fusiform muscle belly deep to the main muscle was found to be arising from medial intermuscular septum reaching the 5th toe. (Fig 1)

The left sole of the same cadaver presented with a tendon to 5th toe arising as deep head from the middle part of tendon of the long flexor and the intermuscular septum (Fig 2), in addition to superficial part of the muscle with the three slips.

Fig. 1: Right sole having a separate slip of flexor digitorum brevis to 5th toe arising deeply from intermuscular septum

Fig. 2: Left sole with a slip of flexor digitorum brevis to 5th toe arising deeply from flexor digitorum longus and intermuscular septum. FDB- Flexor digitorum brevis. FDL- Flexor digitorum longus.

Fig. 3: The insertion of flexor digitorum brevis tendon to the 5th toe at the base of middle phalanx. FDL- Flexor digitorum longus tendon
The pattern of insertion of both these slips was that the tendons passed through fibrous flexor sheath of the toes, splitting at the level of proximal phalanx to enclose the long flexor tendon and uniting to be inserted at the base of plantar surface of middle phalanx (Fig. 3).

**Discussion**

According to standard description in many Anatomy text books, the FDB muscle gives four tendons to the four lateral toes. Each tendon splits into two slips to allow the long flexor tendon to pass through and get inserted on the sides of middle phalanx. Variations in FDB have been reported in literature to occur in 63% of all limbs studied. Absence of FDB tendon to 5th toe was reported by many authors with varied incidence. (6.7% - de Bengoa Vallejo et al, 18.1% - Bulent and Hasan, 38.3% - Nathaniel and 100% - Lobo et al). In the present study, FDB tendon to 5th toe was absent in 25 soles out of 30 soles with an incidence of 83.3%. (Chart 1).

The common variation of FDB tendon to the 5th toe presenting as separate muscular slip was reported to arise from tendon of flexor digitorum longus in 33.3% of 60 feet studied by Nathaniel. In the present study, a low incidence of 3.3% of 30 soles studied showed this variation. The FDB tendon to the 5th toe originating as a separate slip from intermuscular septum was reported in 3% of 33 feet studied by Bulent and Hasan. A similar incidence of this anomaly in 3.3% out of 30 soles was observed in the present study also. Lobo et al observed that all the tendons of FDB inserting on the plantar surface of the base of the middle phalanx in all the 60 soles studied. In the present study, the same mode of insertion was observed in only two soles (6.7%) that had anomalous tendons of FDB to 5th toe while the other soles which showed either absence or presence of tendon to 5th toe followed classical book description.

Claassen and Wree reported the presence of an accessory muscle arising from quadratus plantae to the little toe. Lucaci and Cauwenbergs have also reported the presence of two accessory muscles arising from inferolateral aspect of 1st cuneiform and from medial aspect of calcaneum compensating for the absence of FDB tendon to 5th toe. Some studies noted extreme variations in FDB, like the muscle fusing with lateral and intermediate heads of quadratus plantae in one cadaver and another cadaver presenting FDB as superficial and deep parts with three bellies and four tendons. No such accessory slip/muscle were observed to the 5th toe in the present study. Lobo et al suggested that the minimally utilized FDB tendon to 5th toe may have undergone phylogenetic variation in accordance with Darwin's disuse theory. This is supported by Reeser et al in their electromyographic study of human foot. Comparative analysis of the incidence of absence of FDB tendon to 5th toe in this present study shows geographic clustering with maximum incidence around Asian region (Chart: 1). This signifies the topographic occurrence of evolutionary changes in FDB muscle. Moreover, as this study has been done on cadaveric specimens from northern part of Tamil Nadu, there is a scope and a need for more extensive study of the pattern of presentation of FDB muscle.

**Chart 1**

<table>
<thead>
<tr>
<th>Incidence of Absence of FDB Tendon to 5th Toe</th>
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<tbody>
<tr>
<td>Present report (Asia)</td>
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<tr>
<td>Lobo et al (Asia)</td>
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<tr>
<td>Bulent et al (Asia)</td>
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<tr>
<td>De Bengoa et al (Europe)</td>
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<td>Nathaniel (Europe)</td>
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Asian region ■ European region ◇
Conclusion

The absence of FDB tendon to the 5th toe in 83.3% of 30 soles studied in northern Tamil Nadu region gains relevance with the increasing surgical treatment modalities using FDB muscle. The awareness of the variations of FDB is important to the podiatric surgeon and radiologist during tendon transfer surgeries for claw and hammer toes, musculocutaneous flap for heel pad reconstruction, diagnostic imaging of soft tissue of foot to decrease chances of error while considering options of treatment. A new pattern observed from this study and its geographic clustering around Asian region may act as a corner stone in the studies related to topographic oriented phylogenetic hominid evolution.

References


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