Research Article – Basic and Applied Anatomy

The fourth slip of the flexor digitorum brevis muscle of the human foot. A systematic review and meta-analysis

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Abstract

The flexor digitorum brevis muscle, and in particular its fourth slip, has a significant clinical and surgical importance in medical practice. However, as for the majority of tendons destined to the little toe, the fourth slip is undergoing a phylogenetic degeneration. The aim of this meta-analysis is to conduct an evidence synthesis on the prevalence of FDB-5 and its variants in humans. Twenty-two studies met pre-defined inclusion criteria with a total of 2789 feet and 416 cadavers. Meta-analytical results of fourth slip agenesis were as follows; a) a true prevalence rate of 31.3%, b) a crude prevalence rate of 47%, c) a bilateral prevalence rate of 38.2%, d) a true prevalence rate of 77.3% in Indian populations, e) a true prevalence rate of ≈20% in Japanese, Chinese, American, European and Turkish populations, f) an Odds Ratio of 1.5 significantly in favor for female gender, g) non-significance for hand side, h) a true prevalence rate of a thin fourth slip of 47.7%, and i) a true prevalence rate of the variations of its origin in 12.3%. The knowledge of the frequency of flexor digitorum brevis fourth slip agenesis and variations in relation to the demographic characteristics of patients would be of importance for tendon repair, tendon transfer or soft tissue reconstruction in foot surgery.

Keywords

Flexor digitorum brevis, foot, anatomy, meta-analysis.

Key to abbreviations:

FDB = flexor digitorum brevis
FDB-5 = flexor digitorum brevis slip to the little toe
PPE = pooled prevalence estimate
OR = Odds ratio

Introduction

The flexor digitorum brevis (FDB) is one of those muscles considered undergoing a phylogenetic degeneration (Lobo et al., 2008; Lakshmi, 2010) mainly owing to the various anatomical presentations, such as the absence or the hypotrophy of its fourth slip destined to the little toe.

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The FDB muscle takes origin from the posteromedial calcaneal tuberosity, the posterior third of the deep surface of the plantar aponeurosis, and the lateral and medial intermuscular septa (Sarrafian and Kelikian, 2012). It lies between the abductor hallucis medially and the abductor digiti quinti laterally (Fig. 1). The body muscle then divides into four fascicles each followed by a tendon slip, superficial to the corresponding long flexor tendon and which divides into two slips at the level of the metatarso-phalangeal joint (Testut, 1884). These slips insert on the inferior aspect of the middle phalanx creating a groove for the passage of the long flexor tendon (Rosse and Gaddum, 1997; Williams et al., 2004).

Anatomical variations

The different variations affecting the tendon slips of the FDB may be in the form of agenesis, associated or not to the presence of a small muscular slip from the long flexor or flexor accessorius, or in the form of thin slips. (Nathan and Gloobe, 1974; Sarrafian and Kelikian, 2012). There is an agreement that the tendon slip to the little toe (FDB-5) is much more susceptible to variations compared with slips to other toes. Variations in FDB tendon were noted in 63% of the limbs, involving mostly the fifth toe and to a lesser degree the fourth toe (Nathan and Gloobe, 1974). The average absence of the fourth slip (FDB-5) was estimated at 21.5% (Sarrafian and Kelikian, 2012) and the absence of the slips for the fourth and fifth toes at 3% (Testut, 1884). In

![Figure 1](https://www.schweizerbart.de)
case of absence, a substitute is sometimes observed in the form of a slender fusiform belly from the flexor digitorum longus (FDL) or from the inner tubercle of the os calcis (Wood, 1868; Macalister, 1875).

An unsplit fourth tendon slip has been seen in 5% of subjects and a fusion of this slip with the long flexor was estimated, not counted, at 2% (Testut, 1884; 1892). Smaller slips to the fifth toe were found with a frequency up to 64.5% (Schwalbe and Pfitzner, 1891), and an additional slip from the FDL up to 20% (Nathan and Gloobe, 1974) or from the intermuscular septum in 3% (Yalcin and Ozan, 2005; Gugapriya, 2012). A recent study by Becerro de Bengoa Vallejo et al. (2011) found no cases of variation in the insertion of the FDB tendon into the second, third, or fourth digits in 45 feet.

Clinical relevance

The FDB is related to toe deformities such as the congenital curly toe (Tokioka et al., 2007) and hammer toes. Transfer of the FDB to the proximal interphalangeal joint has been found effective in the prevention of floating toes after Weil osteotomy (Lee and al., 2013) and in toe ulcers of claw- or hammer-toes in diabetic patients (Rasmussen et al., 2013). FDB transfer to the interosseous and lumbrical muscles has been effectively used in treating dynamic claw toe deformity (Errichiello et al., 2012). Transposition of the flexor digitorum brevis tendon has been described for flexible hammer toes (Becerro de Bengoa Vallejo et al., 2008; 2011). Its clinical relevance extends to soft tissue reconstruction; the FDB flap has been used to cover heel and distal plantar defects (Sakai et al., 2001; Attinger et al., 2002).

Aim of research

The aim of this systematic review is to provide more accurate data on the prevalence of FDB-5 tendon slip and its variants.

Methods

The Checklist for Anatomical Reviews and Meta-Analysis (CARMA) guidelines were followed while conducting this review (Yammine, 2014).

Search strategy and identification of studies

A systematic literature search was conducted through a number of electronic databases such as Medline, Embase, Scielo, EBSCO, and Google Scholar from inception to Feb 2014, using the Boolean combination of broad terms such as (“flexor brevis” OR “flexor digitorum brevis” OR “4th slip” OR “fourth slip” OR “flexor digitorum pedis brevis” OR “flexor digitorum communis brevis” OR “flexor digitorum sublimis brevis” OR “flexor digitorum perforatus brevis” OR “pedieus internus”) AND (foot OR pedis OR “fifth toe” OR “little toe”) to locate the maximum number of relevant articles. We also searched the websites of the following journals: Acta Anatomica, Anatomical Record (A and B), Anatomical Sciences International, Annals of Anatomy, Clinical Anatomy, European Journal of Anatomy, European Journal of Morphology, Folia Morpholog-
Criteria for study selection

Literature concerning the prevalence of the variants of the FDB-5 is infrequent, so all published or unpublished studies reporting prevalence rates were included in the review. The primary outcomes are the true or the crude prevalence of FDB-5 or its variants in cadaveric studies. The true FDB-5 prevalence rate is defined as the number of feet affected compared to the number of feet available for study. The crude FDB-5 prevalence is the number of individuals who have either one or two FDB-5 compared to the number of individuals available for study. Secondary outcomes are the prevalence in relation to ancestry, gender, laterality and side, the interactions between those variables, and the variant types of FDB-5. To ensure unbiased selection of included studies, abstracts from conferences were not included. No restriction was imposed on date, language or age. Titles and abstracts were initially screened and full-text articles were obtained when at least one primary outcome was thought to be reported.

Data extraction and analysis

Data extracted included sample size, sample details, type of investigation (clinical or cadaveric), and the results. Analysis was performed using StatsDirect v2.7.8 (StatsDirect, Altrincham, UK). Proportion meta-analysis was used to calculate the pooled prevalence estimate (PPE), and odds ratio (OR) meta-analysis was used to establish potential associations with other variables such as ancestry, gender, laterality or side. The “two independent proportion test” was used to look for significant proportion differences between studies reporting FDB-5 frequencies in different ancestry populations. Descriptive analysis was conducted when the data were not amenable to meta-analysis. We examined heterogeneity amongst studies using $\Gamma^2$ statistics; whenever $\Gamma^2>50\%$, the random-effect estimate was reported.

Results

Search results

The electronic search strategy yielded 197 hits; abstracts of 43 potentially relevant studies were scanned and 10 studies were retained for inclusion. Reasons for exclusion were as follows: 22 case reports and 11 clinical studies with no data on FDB prevalence. Reference checking of the included studies yielded additional 7 studies and their reference checking added another five. In total, 22 studies met our inclusion criteria (Table 1 and 2).
Table 1 – Characteristics of the studies included in the present analysis.

<table>
<thead>
<tr>
<th>Studies</th>
<th>Population</th>
<th>Age</th>
<th>Sample size: cadavers</th>
<th>Male</th>
<th>Female</th>
<th>Sample size: feet</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turner, 1865</td>
<td>British</td>
<td>Adults?</td>
<td></td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wood, 1866</td>
<td>British</td>
<td>Adults?</td>
<td>34</td>
<td>-</td>
<td>-</td>
<td>68</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wood, 1868</td>
<td>British</td>
<td>Adults?</td>
<td>102</td>
<td>68</td>
<td>34</td>
<td>204</td>
<td>102</td>
<td>102</td>
</tr>
<tr>
<td>Schwalbe and Pfitzner, 1889</td>
<td>German</td>
<td>Adults</td>
<td></td>
<td>-</td>
<td>-</td>
<td>132</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Schwalbe and Pfitzner, 1891</td>
<td>German</td>
<td>Adults</td>
<td></td>
<td>-</td>
<td>-</td>
<td>214</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Schwalbe and Pfitzner, 1894</td>
<td>German</td>
<td>Adults?</td>
<td>540</td>
<td>367</td>
<td>173</td>
<td>1080</td>
<td>540</td>
<td>540</td>
</tr>
<tr>
<td>Le Double, 1897</td>
<td>French</td>
<td>Adults?</td>
<td>100</td>
<td>50</td>
<td>50</td>
<td>200</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Adachi, 1900</td>
<td>Japanese</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>226</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Koganei et al., 1903</td>
<td>Japanese</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>292</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Adachi, 1909</td>
<td>Japanese</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>141</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kurz, 1923</td>
<td>Chinese</td>
<td>Adults &amp; children</td>
<td>-</td>
<td>116</td>
<td>30</td>
<td>146</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wagenseil, 1936</td>
<td>Chinese</td>
<td>Adults</td>
<td>-</td>
<td>111</td>
<td>29</td>
<td>140</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nathaniel, 1954</td>
<td>Indian</td>
<td>Adults</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mori, 1964</td>
<td>Japanese</td>
<td>Adults</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nathan and Gloobe, 1974</td>
<td>American</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chaney et al., 1996</td>
<td>American</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>284</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kura et al., 1997</td>
<td>American</td>
<td>50-80</td>
<td>11</td>
<td>8</td>
<td>3</td>
<td>11</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Yalçin and Ozan, 2005</td>
<td>Turkish</td>
<td>33-74</td>
<td>15 cadavers + 3 legs</td>
<td>9 cadav. 7 cadav.</td>
<td>33 (unknown side for 3)</td>
<td>15 out of 30</td>
<td>15 out of 30</td>
<td></td>
</tr>
<tr>
<td>Becerro de Bengoa Vallejo et al., 2008</td>
<td>Spanish</td>
<td>Adults</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>45</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lobo et al., 2008</td>
<td>Indian</td>
<td>Adults</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>60</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Locke et al., 2010</td>
<td>British</td>
<td>71-88</td>
<td>4 (random from 15)</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gugapiiya 2012</td>
<td>Tamil (Indian)</td>
<td>25-70</td>
<td>15</td>
<td>12</td>
<td>3</td>
<td>30</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Illayperuma 2012</td>
<td>Sri Lankan</td>
<td>48-67</td>
<td>135</td>
<td>81</td>
<td>54</td>
<td>270</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>Bernhard et al., 2013</td>
<td>American</td>
<td>-</td>
<td>57 (51 Caucasians, 6 Africans)</td>
<td>33</td>
<td>24</td>
<td>97</td>
<td>48</td>
<td>49</td>
</tr>
</tbody>
</table>
Table 2 – Prevalence of the fourth slip of flexor digitorum brevis (FDB-5).

<table>
<thead>
<tr>
<th>Studies</th>
<th>Sample size (cad./feet)</th>
<th>Absence (Crude/True)</th>
<th>Crude prevalence</th>
<th>True prevalence</th>
<th>Variants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turner, 1864</td>
<td>50 cad. / 100 feet</td>
<td>5 (10%)</td>
<td>-</td>
<td>45 (90%)</td>
<td>-</td>
</tr>
<tr>
<td>Wood, 1866</td>
<td>34 cad.</td>
<td>7 cad. (20.6%)</td>
<td>27 (79.4%)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wood, 1868</td>
<td>102 cad. / 204 feet</td>
<td>10 (10%) / 25 (12.2%)</td>
<td>92 (90.2%)</td>
<td>179 (87.7%)</td>
<td>-</td>
</tr>
<tr>
<td>Schwalbe and Pfitzner, 1889</td>
<td>132 feet</td>
<td>25 (19%)</td>
<td>-</td>
<td>107 (81%)</td>
<td>78 (59%); thin slips</td>
</tr>
<tr>
<td>Schwalbe and Pfitzner, 1891</td>
<td>214 feet</td>
<td>41 (19.2%)</td>
<td>-</td>
<td>173 (80.8%)</td>
<td>138 (64.5%)</td>
</tr>
<tr>
<td>Schwalbe and Pfitzner, 1894</td>
<td>540 feet</td>
<td>135 (25%)</td>
<td>-</td>
<td>405 (75%)</td>
<td>335 (62%); thin slips</td>
</tr>
<tr>
<td>Le Double, 1897</td>
<td>100 cad. / 200 feet</td>
<td>3 (3%) / 19 (9.5%)</td>
<td>87 (87%)</td>
<td>181 (90.5%)</td>
<td>-</td>
</tr>
<tr>
<td>Adachi, 1900</td>
<td>226 feet</td>
<td>42 (18.6%)</td>
<td>-</td>
<td>184 (81.4%)</td>
<td>-</td>
</tr>
<tr>
<td>Koganei et al., 1903</td>
<td>292 feet</td>
<td>66 (22.6%)</td>
<td>-</td>
<td>226 (77.4%)</td>
<td>-</td>
</tr>
<tr>
<td>Adachi, 1909</td>
<td>141 feet</td>
<td>23 (16.3%)</td>
<td>-</td>
<td>118 (83.7%)</td>
<td>-</td>
</tr>
<tr>
<td>Kurz, 1923</td>
<td>146 feet</td>
<td>19 (3%)</td>
<td>-</td>
<td>127 (87%)</td>
<td>-</td>
</tr>
<tr>
<td>Wagenseil, 1936</td>
<td>140 feet</td>
<td>36 (25.7%)</td>
<td>-</td>
<td>104 (74.3%)</td>
<td>-</td>
</tr>
<tr>
<td>Nathaniel, 1954</td>
<td>60 feet</td>
<td>23 (38.3%)</td>
<td>-</td>
<td>37 (61.7%)</td>
<td>21 (35%); slip from a deep head</td>
</tr>
<tr>
<td>Mori, 1964</td>
<td>50 feet</td>
<td>8 (16%)</td>
<td>-</td>
<td>42 (84%)</td>
<td>-</td>
</tr>
<tr>
<td>Nathan and Gloobe, 1974</td>
<td>100 feet</td>
<td>23 (23%)</td>
<td>-</td>
<td>77 (77%)</td>
<td>Additional slip to 5th (20%) or to 4th-5th toes</td>
</tr>
<tr>
<td>Chaney et al., 1996</td>
<td>284 feet</td>
<td>181 (63.7%)</td>
<td>-</td>
<td>103 (36.2%)</td>
<td>(3%); origin from FDL (5%), intermuscular septum (1%), tibialis posterior (1%)</td>
</tr>
<tr>
<td>Kura et al., 1997</td>
<td>11 feet</td>
<td>4 (36.4%)</td>
<td>-</td>
<td>7 (63.6%)</td>
<td>-</td>
</tr>
<tr>
<td>Yalçin and Ozan, 2005 (*)</td>
<td>33 feet</td>
<td>6 (18.2%)</td>
<td>-</td>
<td>27 (81.8%)</td>
<td>12 (36%); thin slips; 1 (3%) separate belly; 1 (3%) slip from intermuscular septum</td>
</tr>
<tr>
<td>Studies</td>
<td>Sample size (cad./feet)</td>
<td>Absence (Crude/True)</td>
<td>Crude prevalence</td>
<td>True prevalence</td>
<td>Variants</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-------------------------</td>
<td>----------------------</td>
<td>------------------</td>
<td>----------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Becerro de Bengoa Vallejo et al., 2008</td>
<td>45 feet</td>
<td>3 (6.7%)</td>
<td>-</td>
<td>42 (93.3%)</td>
<td>-</td>
</tr>
<tr>
<td>Lobo et al., 2008</td>
<td>30 cad./60 feet</td>
<td>60 (100%)</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Locke et al., 2010</td>
<td>4 feet</td>
<td>1 (25%)</td>
<td>-</td>
<td>3 (75%)</td>
<td>-</td>
</tr>
<tr>
<td>Gugapiya 2012</td>
<td>15 cad. / 30 feet</td>
<td>12 (80%) / 25 (83.3%)</td>
<td>3 (20%)</td>
<td>5 (16.7%)</td>
<td>1 (3.3%) separate belly; 1 (3.3%) slip from intermuscular septum</td>
</tr>
<tr>
<td>Ilayperuma 2012</td>
<td>135 cad. / 270 feet</td>
<td>97 (71.8%) / 194 (71.8%)</td>
<td>38 (28.1%)</td>
<td>76 (28.2%)</td>
<td>-</td>
</tr>
<tr>
<td>Bernhard et al., 2013</td>
<td>57 cad. / 97 feet</td>
<td>47 (48%)</td>
<td>28 (49%)</td>
<td>50 (52%)</td>
<td>25 (26%): thin slips</td>
</tr>
</tbody>
</table>

Primary outcomes

True prevalence of FDB-5 absence
Twenty-two studies reported the true prevalence of FDB-5 absence (Turner, 1865; Wood, 1868; Schwalbe and Pfitzner, 1889; Schwalbe and Pfitzner, 1891; Le Double, 1897; Adachi, 1900, 1909 Koganei et al., 1903; Kurz, 1923; Wagenseil, 1936; Nathaniel, 1954; Mori, 1964; Nathan and Gloobe, 1974; Chaney et al., 1996; Kura et al., 1997; Yalcin and Ozan, 2005; Becerro de Bengoa Vallejo et al., 2008; Lobo et al., 2008; Locke et al., 2010; Gugapriya, 2012; Ilayperuma, 2012; Bernhard et al., 2013) with a total of 2789 feet and a PPE of 31.3% (95% CI = 0.208 to 0.427, $I^2 = 97.4\%$).

Crude prevalence of FDB-5 absence
Six studies reported the crude prevalence of FDB-5 absence (Wood, 1866, 1868; Le Double, 1897; Lobo et al., 2008; Gugapriya 2012; Ilayperuma 2012) with a total of 416 cadavers and a PPE of 47% (95% CI = 0.176 to 0.773; $I^2 = 97.5\%$).

Secondary outcomes

Bilateral prevalence of FDB-5 absence
Eight studies reported the bilateral prevalence of FDB-5 absence (Wood, 1868; Schwalbe and Pfitzner, 1894; Le Double, 1897; Adachi, 1900, 1909 Lobo et al., 2008; Gugapriya, 2012; Ilayperuma, 2012) with a total of 776 cadavers and a PPE of 38.2% (95% CI = 0.174 to 0.614, $I^2 = 97.6\%$).

Side-based prevalence of FDB-5 absence
Six studies reported the side of FDB-5 absence (Wood, 1868; Adachi, 1900, 1909 LeDouble, 1897; Lobo et al., 2008; Bernhard et al., 2013) with a total of 469 right and 469 left hands. The pooled OR of 1.1 yielded no significance between hand side (95% CI = 0.766 to 1.602, $I^2 = 0\%$, $p = 0.5$).

Gender-based prevalence of FDB-5 absence
Seven studies reported such occurrence (Wood, 1868; Schwalbe and Pfitzner, 1894; Le Double, 1897; Adachi, 1900, 1909 Lobo et al., 2008; Bernhard et al., 2013) with a total of 790 males and 406 females; the pooled OR result showed that FDB-5 was absent 1.5 times more in females than in males (95% CI = 1.196 to 2.099, $I^2 = 0\%$, $p = 0.002$).

Ancestry-based prevalence of FDB-5 absence
Four studies reported their results in Japanese populations (Adachi, 1900, 1909 Koganei et al., 1903; Mori, 1964) and two studies in Chinese populations (Kurz, 1923; Wagenseil, 1936). The total pooled sample in both populations was 995 feet with a PPE of 19.1% (95% CI = 0.156 to 0.229, $I^2 = 52.3\%$). No significant differences were found between the pooled prevalence values of both populations.

Four studies reported their results in Indian populations (Nathaniel, 1954; Lobo et al., 2008; Gugapriya 2012; Ilayperuma 2012) with a total of 420 feet and a PPE of 77.7% (95% CI = 0.489 to 0.965, $I^2 = 96.6\%$).

Ten studies reported their results in American/European populations (Turner, 1865; Wood, 1868; Schwalbe and Pfitzner, 1889, 1891; Le Double, 1897; Nathan and
Gloobe, 1974; Chaney et al., 1996; Kura et al., 1997; Becerro de Bengoa Vallejo et al.,
2008; Locke et al., 2010) with a total of 1244 feet and a PPE of 21.2% (95% CI = 0.097
to 0.356, I² = 96.6%).

Only one study reported the frequency of FDB-5 in a Turkish population (Yalcin
and Ozan, 2005) with an absence rate of 18.2%.

The two independent proportion test yielded a difference of ≈45% (p <0.0001)
between Indians and all other studied populations.

**True prevalence of thin slips**

Four studies reported the occurrence of a thin slip of FDB-5 in their samples
(Schwalbe and Pfizner, 1889, 1891; Yalcin and Ozan, 2005; Bernhard et al., 2013) with
a total of 476 feet and a PPE of 47.7% (95% CI = 0.294 to 0.662, I² = 93.5%).

**True prevalence of the variations in the origin of FDB-5**

Four studies reported the variation in the origin of the muscle (Nathaniel, 1954;
Nathan and Gloobe, 1974; Yalcin and Ozan, 2005; Gugapriya 2012) with a total 223
feet and a PPE of 12.7% (95% CI = 0.028 to 0.283, I² = 87.7%). The observed variations
include a separate belly from FDB, a slip from flexor digitorum longus, and a slip
from the intermuscular septum.

**Discussion**

**Summary of main findings**

Sarrafian and Kelikian (2012) reported an average absentee true rate of FDB-5 of
21.5%. However, their calculation was done as a mean value from five studies where
one value, that of Le Double (1897), was in fact a crude, not a true frequency value.
Our pooled results yielded higher prevalence values; the true and crude prevalence
of the agenesis of FDB-5 were of 31.3% and 47%, respectively. A thin slip was found
in half cases; meaning that only in about 1 foot out of 5 (20%) the slip for FDB-5 was
considered by authors as having a “normal” size. Bilateral agenesis of FDB-5 was
found to be high, 38.2%. While no significance was found for hand side, FDB-5 was
1.5 times significantly less present in females than in males. Ancestry-based results
demonstrated that Indian populations have significantly higher rate (∼77%) of FDB-5
absence when compared to Japanese/Chinese, American/European and Turkish pop-
ulations (∼20%). This review reveals that there is a genetic basis for the involution of
the fourth slip of the FDB muscle. While the variation of the distal insertion of FDB-5
was exceptionally reported, four studies reported the prevalence of variations in its
proximal origin to be ∼13%.

**Limitations and possible bias**

Despite an extensive search strategy, no confirmation could be provided that this
review located all relevant articles. However, the pooled sample sizes of 2789 feet and
416 cadavers used in meta-analyses could be fairly considered as representative to
draw prevalence estimates for the agenesis of the fourth slip of the FDB muscle. On
the other hand, due to the lack of available reported data, our analyses did not cover all populations, mainly the African and Middle Eastern ancestries. Future research should be oriented to investigate the frequency of fourth slip to the little toe in those populations.

In conclusion, this evidence-based anatomical review attempted to provide an accurate frequency of the fourth slip of the FDB muscle and its variants in the human foot. Surgeons should be aware of the high rates of agenesis and smaller size of this slip when considering it for tendon repair, tendon transfer, or flaps soft tissue reconstruction.

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References


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