

# THE ORIGIN AND THE DEVELOPMENTAL EXPLANATION OF SOME KNOWN VARIATIONS OF FLEXOR DIGITORUM SUPERFICIALIS AND PROFUNDUS

I. DYLEVSKÝ

The literature relating to variations of muscles is very comprehensive. The variations of antebrachial muscles were mostly treated from the anatomical, anthropological, and clinical points of view (Macalister, 1872, Schaffer, 1909, Thompson, 1921, Žlábek, 1933, Kaplan, 1953, Bunnell, 1951, Jones, 1966).

The authors' attention, however, focused largely on the description of varieties (e.g. Žlábek, 1933, Macalister, 1872) or on the description of their occurrence in large races (Thompson, 1921, Loth, 1931).

The anatomic description of varieties are exact and statistical data concerning their occurrence do not differ significantly in the works of the respective authors. The muscular varieties found in the individual races (Thompson, 1921, Loth, 1931) are to be accepted only with great reserve. These works frequently confuse the conception of a race and that of a nation, so that the results obtained are incomparable.

The attempts at an explanation of hereditary relationships of the muscular varieties are lacking basic genetic examinations, and rely merely on random gene logical findings.

A developmental explanation of the morphogenesis of muscular varieties, however, is mostly missing due to little knowledge of the ontogenesis of the muscular system of the extremities. In our report, we will try, on the basis of our information concerning the evolution of the superficialis and profundus flexor digitorum of the hand, to explain the origin of certain known varieties of these two muscles.

The typical variations of the muscles studied can be divided into the following two groups:

1. Variations in the volume and external morphology of the venter of both muscles and in their relation to the adjacent muscles.
2. Variations in the number and shaping of the tendons of both muscles, especially of their insertion parts.

One type of variations is related to the venter of flexor digitorum superficialis et profundus (Žlábek, 1933, Loth, 1931). Often a superficial flexor may be found whose muscular venter does not reach the place of its normal beginning on the epicon-

dylus ulnaris humeri and under the linea supinatoria radii, but begins more distally from both antebrachial bones. Also the extension of the muscular mass in the distal part of the muscle, in the place of its transition into a tendon, is variable. The muscular venter reaches differently far into the canalis carpi, where it often extends accessory fascicles inserted into the retinaculum flexorum and the antebrachial fascia (Testut, 1884, Double, 1897). As the most frequent variation of the venter of the flexor digitorum profundus the literature mentions its connection with the flexor pollicis longus (Loth, 1931).

The other group is formed of variations relating to the number and formation of tendons of both muscles, particularly of their insertion parts. The medial part of the tendon of flexor digitorum superficialis is missing, but its rudiment at the muscular venter sometimes remains. Distally remain the insertion branches with a part of the tendon that springs from the tela fibrosa of the saccus carpi medius (Žlábek, 1933).

The most frequent variation of tendons pertaining to the flexor digitorum profundus is fusing of tendons of the individual fingers and the creation of fibrous junctions among them.

If we want to understand the morphogenesis of the given varieties of flexor superficialis et profundus, we must follow the way of development of both muscles.

Gräfenberg (1906) described the occurrence of two bases of flexor digitorum superficialis.

The first — the proximal base extending from the proximal border of the ulna as far as the medial part of the ulna — is called by Gräfenberg flexor digitorum sublimis.

The second — the distal base is described by him in the carpal region and called flexor digitorum brevis.

According to Gräfenberg, both bases fuse during further growth and constitute a united flexor digitorum superficialis.

Of interest is his note that on the fingers are differentiated merely the tendons of flexor profundus (his observation is not more closely defined). Thus Gräfenberg's description admits the explanation of independent differentiation of the insertion part of the superficial flexor tendon in situ in the area on the



palmar side of the first phalanx. He does not deal any further with the development of the tendons of both flexors.

According to our observations (Dylevský, 1967), however, the base of flexor digitorum superficialis is merely one well-bordered muscular blastema lying in the palm and in canalis carpi (Fig. 1).

In a 16-mm embryo it extends from the centre of

metacarpi proximally as far as the base of radiocarpal juncture. Thus a picture is visible, where only flexor digitorum profundus is differentiated on the fore-arm, and the superficialis flexor is actually a hand muscle situated in the palm (Fig. 2).

The n. medianus lies directly in the subcutis on the base of the flexor profundus.

In the course of further development the blaste-

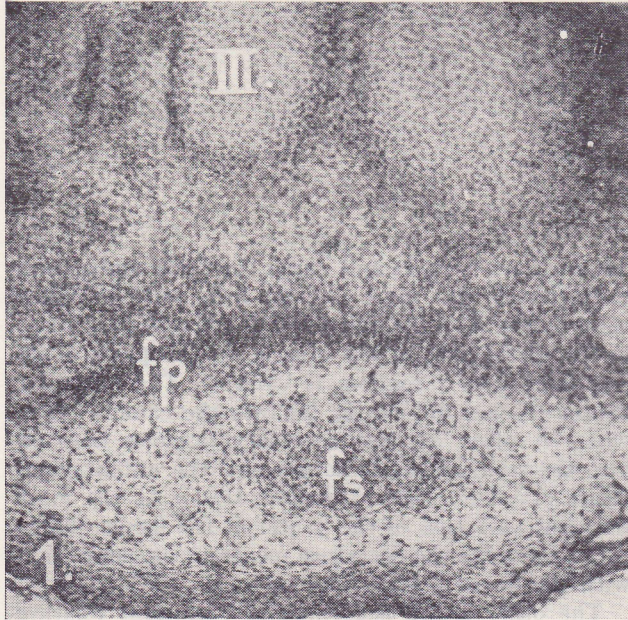


FIG. 1

A transverse section through the right hand at the level of metacarpal bases. Verticococcygeal length: 19.4 mm; fp = flexor digitorum profundus; fs = flexor digitorum superficialis; III = a section through the base of the third metacarpus.

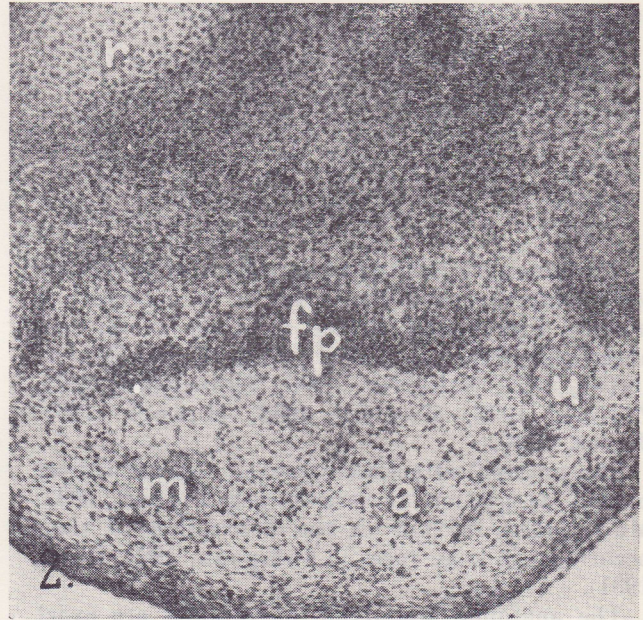


FIG. 2

A transverse section through the centre of the right forearm. Verticococcygeal length: 19.4 mm; fp = flexor digitorum profundus; a = the sparse mesenchyme on the volar side of the forearm; u = n. ulnaris; m. = n. medianus; r = radius.

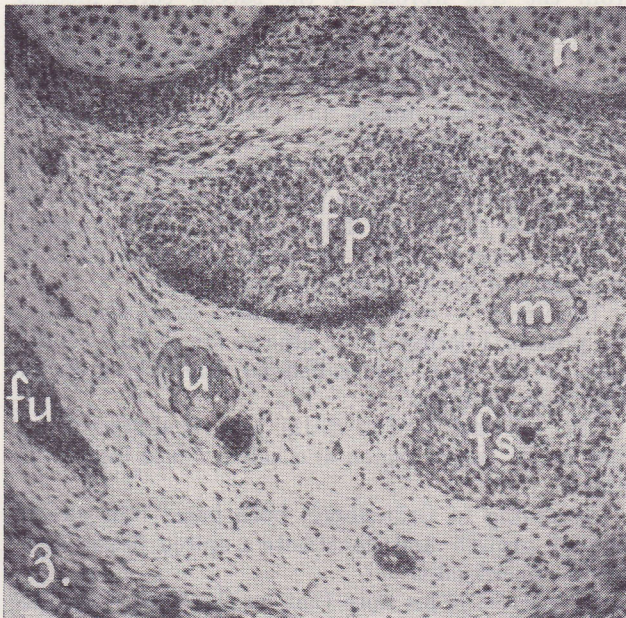


FIG. 3

A transverse section through the middle of the left forearm. Verticococcygeal length: 22.0 mm; fp = flexor digitorum profundus; fs = flexor digitorum superficialis; fu = flexor carpi ulnaris; m = n. medianus; u = n. ulnaris; r = radius.



FIG. 4

A transverse section through the right hand at the level of the distal row of carpal bones. Verticococcygeal length: 27.0 mm; fp = flexor digitorum profundus; f = flexor pollicis longus; rf = retinaculum flexorum; c = os capitatum.



matic base of flexor digitorum superficialis becomes enlarged in the proximal direction onto the fore-arm towards the site of its future origin in the ulnar region (Fig. 3).

We have not found the muscular base situated proximally as described by Gräfenberg.

The differentiation of tendons of flexor superficialis et profundus begins in embryos having a 15 to 16 mm verticococcygeal length.

The differentiation passes from the ulnar side of the flexor profundus in the form of a cellular band. By the tendons of flexor pollicis longus it is connected with the tendons of the flexor digitorum profundus.

Thus the tendons become differentiated throughout the whole length of the forearm, carpus, and fingers in situ, and likewise in all sections. The articulation of the originally homogeneous base of tendons of the flexor profundus into the tendons for the respective fingers begins in the metacarpal region closer to the metacarpal capitula and proceeds slowly in the disto-

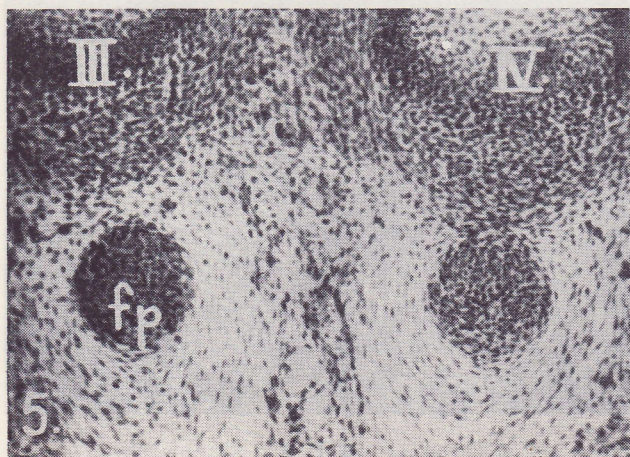


FIG. 5

A transverse section through the right hand at the level of metacarpal capitula. Verticococcygeal length: 17.0 mm; fp = flexor digitorum profundus; III, IV = capitula of the third and the fourth metacarpus.

proximal direction. First, the base of the tendon of flexor pollicis longus becomes separated (Fig. 4). After its separation, the distribution of the tendinous bases for the other fingers continues rapidly. Thus we can see that the tendons of the flexor profundus develop from an originally uniform disk.

The tendons for the respective fingers develop then through the division of this disk into individual sections.

Quite differently proceeds the differentiation of the tendinous bases of flexor digitorum superficialis.

The blastema of this muscle which arises in the carpal region extends distally, towards the second to the fifth finger, four cusps formed by streams of myoblasts reaching as far as the capitula of the metacarpi, where, in the further distal course, they are replaced by fibroblasts and fuse then with the tendinous bases of the flexor profundus.

This fusion in the transverse sections looks like this:

First, a mere attachment of the flaps of flexor digitorum superficialis to the fundament of the tendons of flexor profundus occurs. When the bases of the flexors come closer to each other, flexor digitorum superficialis thins out and disappears (Fig. 5). The section, in the course of which the two tendons become attached and fuse, extends from the middle of the metacarpal length to the capitula of the metacarpi.

This section differs in length in the individual 17 to 19-mm embryos according to the growth of the extremity skeleton, however, it remains unchanged in skeletotypical respect.

Thus, until the verticococcygeal length of 19 mm is reached, fetuses have only fundaments of the flexor profundus tendons created in the digital area (Fig. 5). The insertion branches of flexor superficialis have not been found in fetuses of this length. Neither is the chiasma formed as yet.

In fetuses longer than 19 mm a gradually denser and denser mesenchyme is found in the region between

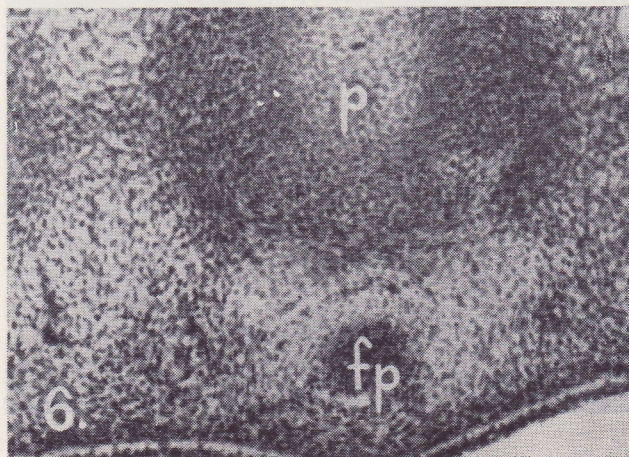


FIG. 6

A transverse section at the level of the first phalanx to the third finger of the left hand. Verticococcygeal length: 16.0 mm; fp = flexor digitorum profundus; p = phalanx I.

the palmar surface of the first phalanx and the tendon of flexor profundus (Fig. 7).

This mesenchyme in situ forms in bands, from which subsequently the two branches of flexor digitorum superficialis differentiate and the base for the chiasma is formed.

The definite fundament of both branches constitutes only in 20-mm embryos, when the differentiation of the apparent base of lig. vaginale in the area of the first phalanx is also completed (Fig. 8).

Only in embryos having a verticococcygeal length of 25 mm, the differentiation of the tendons flexor digitorum superficialis is sufficient also proximally from crossing with the flexor profundus.

The insertion branches of the flexor superficialis together with their chiasma form in situ, secondarily from the mesenchyme between the tendons of flexor profundus and the palmar surface of the first phalanx.

A description of the development of the two musc-



les permits to explain the variations stated above. The muscular venter of flexor digitorum profundus proceeds, in the course of development, gradually to the forearm to the place of its insertion. If it does not reach its beginning in the ulnar region, a typical variation is found, the beginning of the muscle being shifted distally to the forearm. The position of the muscular blastema of the flexor superficialis in the carpal region enables also to explain the muscular slips with the fibrous formations of canalis carpi. Such a variation is also seen as a condition pointing back to the ontogenetic past.

Variations in the number and the formation of the tendons of the two flexors digitorum may only be

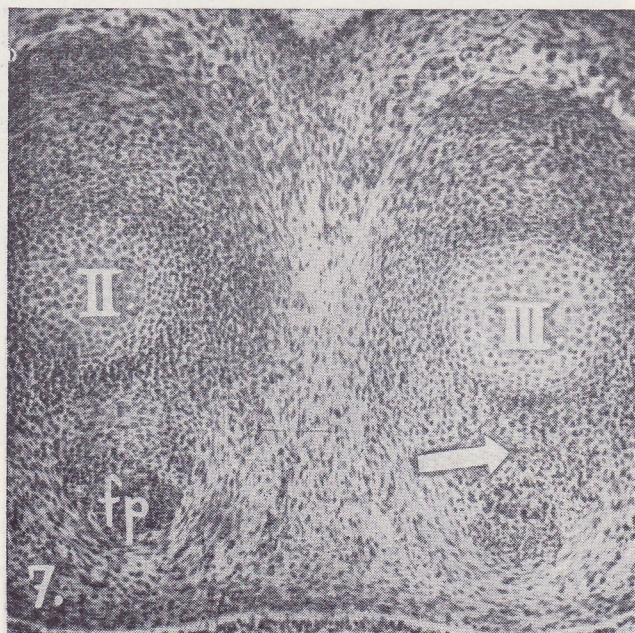


FIG. 7

A transverse section at the level of the first and the second phalanx to the second and third fingers of the left. Verticococcygeal length: 17.0 mm; fp = flexor digitorum profundus; II, III = the second and third phalanges; the arrow indicates the place of thickening of the mesenchyme, formation of the insertion part of the flexor digitorum superficialis.

understood from the ontogenesis of the tendons of the two flexors.

Such cases of variations where the tendons of the flexor digitorum superficialis are deficient, but the insertion part with the chiasma are maintained, are easily explicable on the example of the described course of the differentiation of tendons pertaining to flexor digitorum superficialis.

The insertion part differentiated typically independently in situ. The medial part of the tendon differentiating from the distal end of the fleshy part of the muscle had not formed, or there developed only short tendinous bands in the forearm.

The insertion branches of the flexor superficialis are, therefore, separated from the proper muscle and begin with a short chord from the adjacent tela fibrosa, or attach themselves to the tendons of the flexor digitorum profundus.

A different development of the tendons of the

profundus flexor which originate through the division of the uniform tendinous disk (equally throughout the whole length of the forearm, hand and fingers) provides an easy explanation of the cases exhibiting a varying degree of tendon fissures, various proportions of the muscular and chordal parts of the flexor profundus, and also of the origin of various intertendinous ligaments.

Thus all variations described are explicable from their ontogenesis. We are convinced that they have no phylogenetic foundation, and that they are mere deviations of the individual ontogenesis, from whose course they can formally be derived morphogenetically.

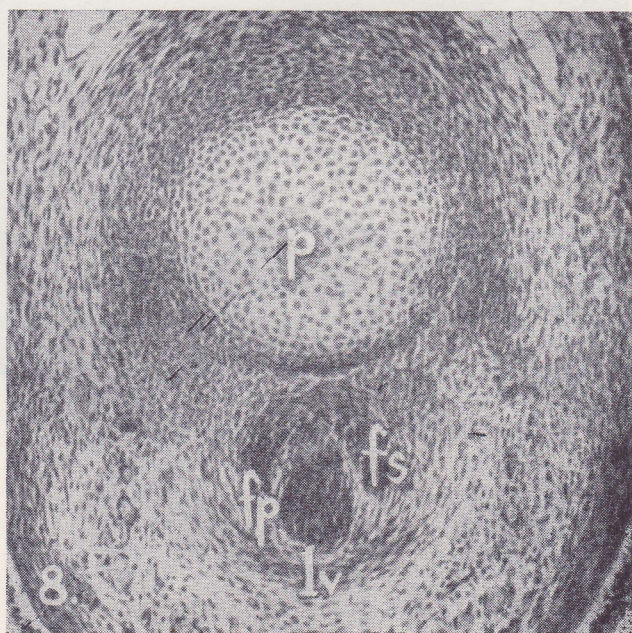


FIG. 8

A transverse section at the level of the first phalanx to the third finger of the right hand. Verticococcygeal length: 25.0 mm; fp = flexor digitorum profundus; fs = flexor digitorum superficialis; lv = lig. vaginale of the first phalanx.

#### SUMMARY

1. The way of forming of the flexors superficialis and profundus described by us differs from literature data:

- a) The two muscles develop independently in two separated strata. Flexor digitorum superficialis arises from an independent muscular blastema in the carpal region. Its muscular venter increases proximally in the direction of the forearm.
- b) The tendons of flexor digitorum profundus develop in situ as a disk extending from the forearm to the palm and splitting distally into the tendon fundament for the respective fingers.
- c) Differentiation of the tendons of the superficialis flexor proceeds like this: From the muscular blastema of flexor digitorum super-



ficialis separate flaps of muscular mass, which become attached to the palmar surfaces of the tendons of the flexor profundus. The insertion branches of the flexor superficialis together with their chiasma are formed in situ, secondarily, from the mesenchyme between the tendons of the flexor digitorum profundus and the palmar surface of the first phalanx.

2. The above description of development of the flexors digitorum superficialis et profundus permits to present an explanation of the basic variations of the two muscles.

- a) The extent of the muscular venter of the flexor superficialis and the site of the latter's beginning depend on the extent of shifting the muscular blastema on the forearm during the embryonal period.
- b) The absence of the tendon of the flexor digitorum superficialis with the insertion part and the chiasma formed is explicable by the independent differentiation of the insertion part of the tendon so as it has been described in the development of the tendons of the flexor superficialis.
- c) The variously progressed fissure of the tendons of the flexor profundus and the various proportions of the muscular and chordal parts of the muscle are given by the not always equal division of the originally uniform tendinous disk.

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- MUDr. Dylevský Ivan, Anatomický ústav Lékařské fakulty Karlovy University, U nemocnice 3, Praha 2