CHAPTER I

Anatomy and Embryology of the Palmar Aponeurosis

Thorough knowledge of the structure of the palmar aponeurosis is necessary in order to understand the symptomatology of Dupuytren's contraction and to perform the surgical intervention required. More general interest was aroused in these anatomical questions only after DUPUYTREN (1832) had demonstrated that changes localized to the aponeurosis were the cause of this deformity of the hand.

1. General Survey of the Anatomy and the Writer's Opinion Concerning the Digital Extensions of the Palmar Aponeurosis

The description of the fascial framework of the palm given in this chapter agrees in its principal traits with earlier descriptions. The writer was able to verify these by means of ten post-mortem dissections and the examination of a similar number of cases operated on for Dupuytren's contraction.

In describing this fascial system, of which the palmar aponeurosis forms a complex supporting linkage, it has been found convenient to adopt a general classification.

1. *The superficial palmar fascia* (Fig. 1), usually called ***the palmar aponeurosis***, is separated from the palmar skin by adipose tissue of a particular structure. It is triangular in shape with the point directed towards the wrist. Its longitudinal fibres consist partly of a continuation of the tendon to the palmaris longus muscle. This is, however, the most variable muscle in the human body and according to THANE (1892) is lacking in about 10 per cent or according to KALBERG (1935) in 12.5 per cent. When the palmaris longus is absent the palmar aponeurosis is attached in varying ways to the antebrachial fascia.

In Skoog, T: Dupuytren's Contraction With Special Reference To Aetiology And Improved Surgical Treatment Its Occurrence In Epileptics Note On Knuckle-Pads. Acta Chirurgica Scandinavica 1948;vol 96, Suppl 139.

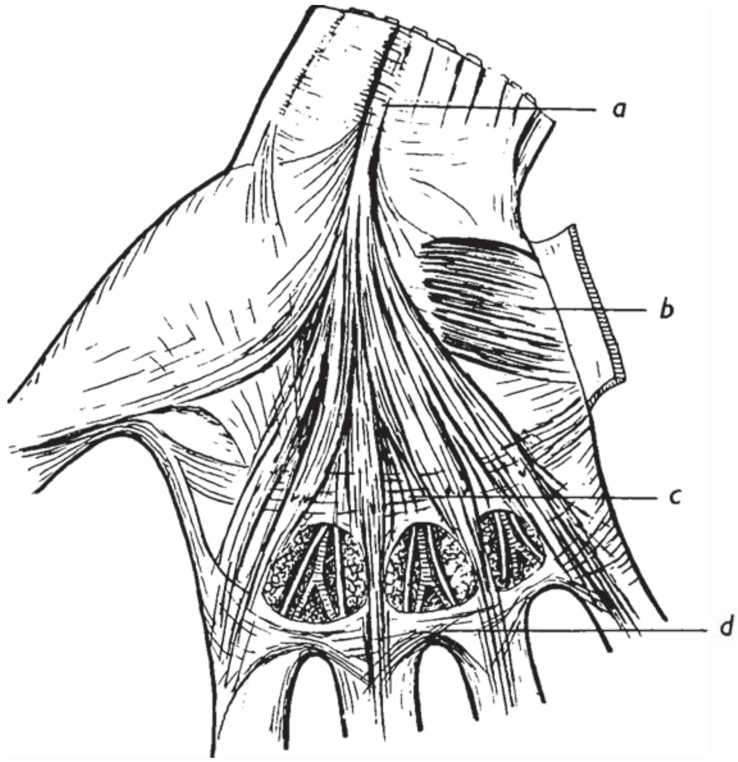

Fig. 1. Palmar aponeurosis (superficial palmar fascia); modified from POIRIER, CHARPY (1901). a — palmaris longus tendon; b — palmaris brevis; c — transverse fibres; d — natatory ligament.

The sides of the aponeurosis continue along the thenar and hypothenar regions and are reinforced in their course by two fasciculi which originate interdigited from the transverse carpal ligament. On the ulnar aspect this reinforcement consists of a marked fibrous band. The corresponding band along the thenar eminence is considerably thinner. In general, the aponeurosis is most strongly developed on the ulnar aspect.

The palmar aponeurosis is built up of fibres, which can be divided into three groups, according to their course:

a) *the longitudinal fibres* (Fig. 1) form the principal part of the aponeurosis. LEGUEU and JUVARA (1892) divided these into two groups: "les languettes prétendineuses" and, between them, the thinner "languettes intertendineuses". The former extend as four separate slips on the volar aspects of the fingers, where they partly merge into the fasciae of the fingers and partly attach to the skin. The above-mentioned writers also described two more distinct bands in the latter group, attached one on each side of the finger-base.

In one case with retraction of the palmar aponeurosis, dimpling of the skin, corresponding to the insertion of these bands, was observed.

b) *the transverse fibres* (Fig. 1) strengthen the palmar aponeurosis transversely and form, over the distal part of the palm, a distinct group. Superficial transverse fasciculi, as well as a number of oblique fibres, form the interdigital ligaments in the finger webs (Braune's or Gerdy's natatory ligaments). There is also a similar ligament in the thumb web although it is less developed and is not always in continuity with the others. FROHSE (1906) differentiated between a volar and a dorsal section of these bands. Close to and proximal of the natatory ligaments are small triangular defects or considerable thinnings of the aponeurosis. When the fingers are stretched, the fat of the palm protrudes through these gaps and gives rise to the so-called *monticuli*.

c) *the superficial fibres* which run obliquely towards the skin are most numerous at the level of the metacarpal heads where they give rise to the distal palmar crease. These fibres, which unite the aponeurosis tightly to the skin, are of particular interest since this attachment produces the dimpling of the palmar skin which is often a sign of Dupuytren's contraction.

2. ***The deep palmar fascia*** covers the palmar arch, beneath the flexor tendons, and is attached to the volar aspects of the metacarpal bones. It is reinforced peripherally by transverse fibres which form the transverse metacarpal ligament.

3. ***The connexions between the palmar aponeurosis and the deep palmar fascia***, consisting of septa along the sides of the flexor tendons, are of considerable importance. These septa subdivide the middle space of the palm into eight fascial channels (Fig. 2). In four of these run the flexor tendons enclosed in their sheaths. The other four contain the lumbrical muscles as well as the common digital vessels and nerves, which are also enclosed in a separate thin layer of connective tissue. At the level of the metacarpophalangeal joints a number of septal fibres perforate to the dorsal aspect of the hand, traversing each other in such a way that the heads of the metacarpal bones can be shifted elastically in relation to each other (Fig. 3). The septa towards the muscles of the thenar and hypothenar eminences are the most strongly developed.

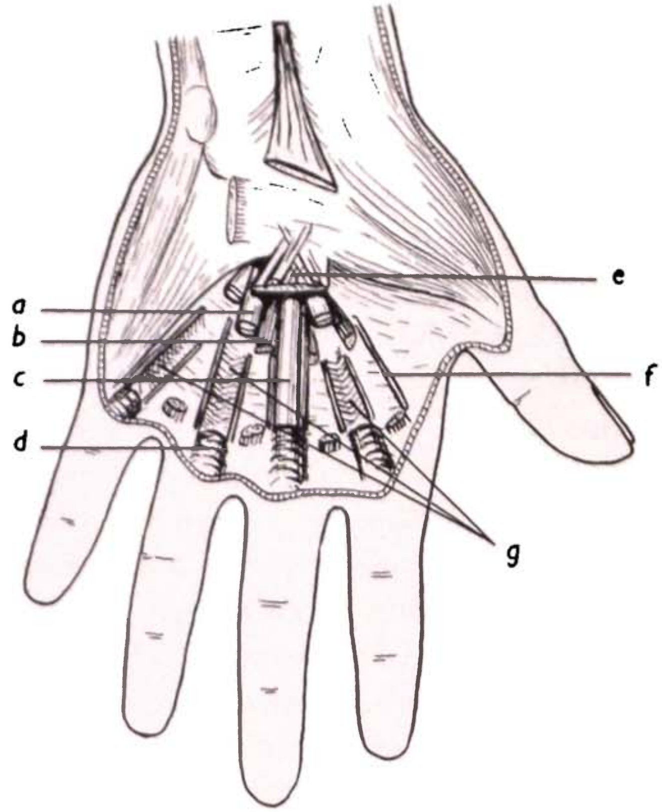

Fig. 2. Palm of hand with palmar aponeurosis removed; modified from LEGUEU, JUVARA (1892).

a — cut flexor tendons; b — proximal part of a lumbrical muscle; c — flexor tendons to middle finger left in position; d — vaginal ligament; e — deep attachments of palmar aponeurosis to transverse carpal ligament; f — deep attachment of palmar aponeurosis forming longitudinal paratendinous septum; g — deep aspect of the fibrous tendon sheaths formed by the paratendinous septa, flexor tendons removed.

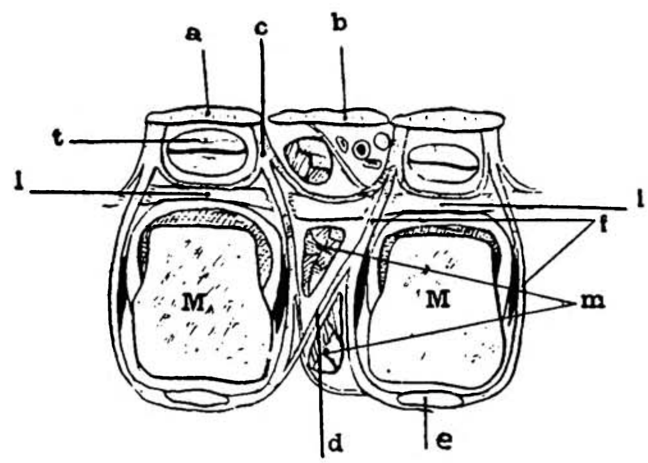

Fig. 3. Diagram showing cross section of the hand at the level of the heads of the metacarpal bones (M); from LEGUEU, JUVARA (1892). Cf. Fig. 12.

a — pretendinous band; b — intertendinous band, covering the lumbrical muscle, digital nerve and vessels (a and b together form the palmar aponeurosis); c — longitudinal septum attached to the deep palmar fascia, in this region partly penetrating the transverse metacarpal ligament (l) reaching the dorsal aspect of the hand as shown (d and f); e — extensor tendon; m — interosseous muscles; t — flexor tendons.

DUPUYTREN noted that the paratendinous septa which he described as bifurcations of the fascial bands for the passage of the flexor tendons are also attached to the sides of the bony proximal phalanges. There they form relatively strong longitudinal septa in continuation with the digital fascia (Fig. 4). In addition, some oblique fibres are attached to the expansion of the extensor tendon. KANAVEL et al. (1929) in

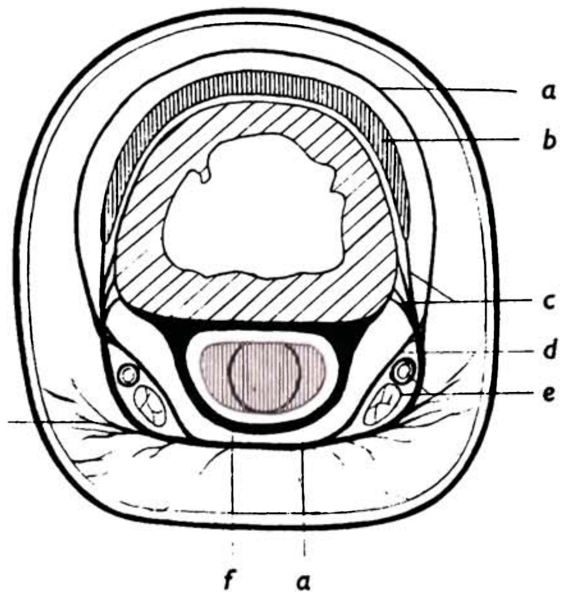

Fig. 4. Diagram of digital fascia; cross section of a proximal phalanx.

a — digital fascia; b — expansion of extensor tendon; c — longitudinal septal attachment of palmar and digital fascia to the sides of the bony phalanx and to the extensor tendon; d — deep layer of digital fascia; e — digital nerve and artery; f — vaginal ligament enclosing the flexor tendons; g — fibres to the skin.

their careful investigation of the palmar fasciae described the digital continuation of the paratendinous septa as a deep layer of the digital fascia, and regarded it as a definite structure well-defined from a superficial layer. Between these layers lie the digital nerves and vessels. *In the writer's dissections some of the fibres to the dorsum of the finger were seen running in an oblique direction, with a definite portion reaching as far as the dorsal aspect of the proximal interphalangeal joint and the base of the second phalanx. The diagram in Fig. 4, showing the arrangement of the digital fascia, is based on the writer's dissections.*

In the majority of textbooks of anatomy the palmar aponeurosis is depicted as limited laterally by the medial border of the thenar eminence. GRAPOW (1887) as well as other writers stated, however, that it should be possible to observe a band to the thumb crossing the pollicis brevis muscle. The question whether there is in fact an extension to the thumb is of interest, since Dupuytren's contraction can also involve this member. Later investigations show that this extension is not always present. HARPER (1935) stated that in most cases there was an extension of considerable thickness from the aponeurosis to the adjacent surface of the thenar eminence. In five cases he found that this extension was prolonged towards the metacarpophalangeal joint of the thumb. In one case it was continued into and fused with the tendon sheath of the flexor pollicis longus. KALBERG (1935) found, on dissection of 400 hands, that an extension to the thumb was lacking in 68 per cent. In his material there were also variations as regards the extensions to the other fingers. They varied in number from three to seven; thus in some cases there were two extensions to the same finger. In exceptional cases some fingers lacked an extension. In 2 per cent of such cases the extension to the ring finger was lacking. The present writer's material is too small to allow of any conclusions in this respect.

The aponeurotic tissue is poorly supplied with blood. In the present writer's normal material it was possible to observe microscopically a few fine vessels from the surface branching among the fibre bundles. From a surgical viewpoint a statement made by ANSON and ASHLEY (1940) is important, i. e. that the arteries which anastomose with the deep and superficial vessels pass through the tissue of the paratendinous septa.

Innervation is also sparse, but occurs in the form of free end-organs (Golgi-Mazzoni and Vater-Pacini corpuscles). The latter are more common and are particularly localized to the surfaces of the aponeurosis (Fig. 5). They vary considerably in size and are at times visible macroscopically. Similar observations regarding innervation were made earlier by PORSIO (1932).

Function

The palmar aponeurosis was for long regarded as a protection for the anatomical structures of the palm. DUPUYTREN mentioned its importance as a reinforcement of the arch of the hand. He was also of the opinion that it tended constantly to bring the fingers into a semi-flexed position, normally their position of repose, and believed that an exaggeration of this function gave rise to the deformity. This theory is of minor interest, but there is no doubt that the pretendinous bands counteract hyperextension of the fingers.

Fig. 5. Four Vater-Pacinian corpuscles. Stained with haematoxylin-eosin. Photomicrograph. (× 25.)
a — deep surface of the palmar aponeurosis.

After DUPUYTREN, GRAPOW in particular investigated the function of the aponeurosis. He was of the opinion that, amongst other functions, it contributed to ensuring the grip of the hand since the tense fixation of the aponeurosis to the skin prevents this slipping. The skin would otherwise, when gripping firmly, slide like a glove. BRAUNE and TRÜBIGER (1873) emphasized the circulatory significance of the aponeurosis, since by alternate stretching and relaxation it contributes to the flow of both blood and lymph. LEGUEU and JUVARA considered that the long transverse fibres across the heads of the metacarpal bones were of particular importance in keeping the flexor tendons in position. In actual fact, this occurs solely through the strong fibrous sheaths enclosing the tendons at the base of the fingers (the vaginal ligaments). Moreover, complete excision of the palmar aponeurosis causes no bow-string effect nor any other functional disturbance of the flexor tendons. FROHSE made particular mention of the importance of the natatory ligaments in preventing overspreading of the fingers and in limiting the movement of individual fingers in the metacarpo-phalangeal joints.

Less attention has been paid hitherto to the functional significance of the more pronounced development of the aponeurosis on the ulnar aspect. In the active phase, in movements of precision in particular, the plentifully muscled radial part of the hand is most used, whereas in gripping the ulnar region of the hand serves as a support and is particularly important in retaining a firm grip. The stronger development of the aponeurosis on the ulnar aspect as a passive protection and supporting mechanism appears, from this point of view, as particularly suited to the purpose. It also implies greater functional strain on the aponeurosis at this site.

The framework formed by the palmar aponeurosis and its connexions retains the anatomical structures of the palm in constant relation, and its other functions, mentioned above, are also more or less evident. This does not, however, imply that the palmar aponeurosis is functionally necessary. It will be seen later in this paper that aponeurosectomy does not seem to cause any remarkable inconvenience to an adult.

2. Embryology

Little interest has been accorded hitherto to the development of the palmar aponeurosis in man. Gräfenberg (1905) states that the tendinous continuation of the palmaris longus muscle extends into the palmaris brevis muscle at an early stage. Ferrarini (1935) amongst other observations asserted that the palmar aponeurosis in the embryonic state does not extend distal to the metacarpophalangeal joints and is thus not attached to the phalanges. He considered that the transverse fibres develop independently of the longitudinal fibres.

The Writer's Observations

Since the embryology of the palmar aponeurosis has played a considerable rôle in the discussion concerning the aetiology of Dupuytren's contraction, the present writer examined systematically by means of serial sections the palmar aponeurosis of twenty human embryos and foetuses from 1.5 to 16 cm in length. The results of the investigation were as follows:

In 1.9 cm embryos the aponeurosis was seen as a well-defined plaque in the palm. It consisted of axially directed masses of cells forming a direct continuaiton and broadening of the palmaris longus tendon. At this stage it only extended somewhat proximally of the heads of the metacarpal bones. On a level with these was seen a separate proliferation of the mesenchyme with a transverse arrangement of structures from which are developed the transverse fibres characteristic of the aponeurosis in this region at the adult stage. These are thus formed independently and it is possible to observe

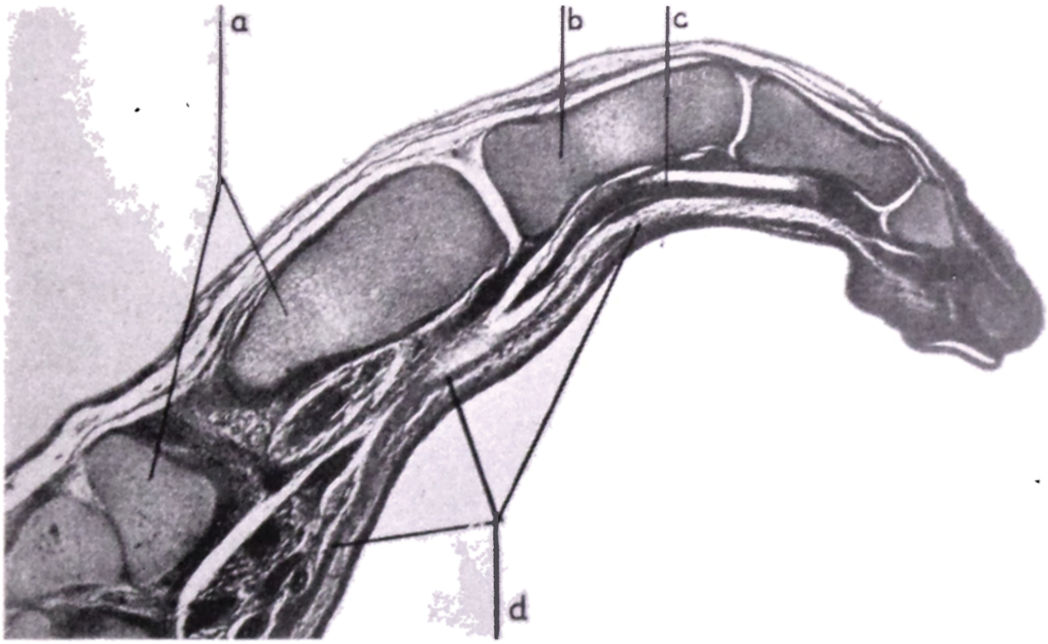

Fig. 6. Longitudinal section of the hand along the axis of the little finger in a 5.1 cm human foetus. Silver-impregnated. Photomicrograph (25.)
The palmar aponeurosis (d) is seen extending to the distal third of the proximal phalanx (b). a — metacarpal bone; c flexor tendon.

during development how the extensions of the palmaris longus tendon merge with them. Already at this stage, the septal connexions between the palmar aponeurosis and the deep palmar fascia were marked.

In the 3—5 cm embryonic stage the development of the aponeurosis had continued in a distal direction, so that the digital extensions could be seen along the proximal phalanges (Fig. 6).

Figs. 7—11 show the aponeurosis in a 6.5 cm human embryo. It was possible at this stage to see how the palmaris longus tendon was attached to the transverse carpal ligament and thence spread in a manner which to a great extent corresponded to the topography of the aponeurosis in adults. In the distal part of the palm appeared longitudinal septa which divided the subaponeurotic space into fibrous canals for the flexor tendons, and between them the lumbrical muscles and the digital nerves and vessels. The particular distribution of the digital extensions of the aponeurosis and the digital fasciae could be traced already at this stage (Fig. 11). The natatory ligaments were originally formed as independent structures and only secondarily joined the aponeurosis (Fig. 10). This fact is noteworthy, since at a state of full development the fibrous supporting mechanism of the palm is regarded as an entity.

At the 16 cm stage all the parts of the palmar aponeurosis and its connexions could be discerned. The section in Fig. 12 gives an almost

Figs. 7—11. Transverse sections at different levels of the hand in a human foetus at the 6.5 cm stage. Stained with haematoxylin-eosin. Photomicrographs.

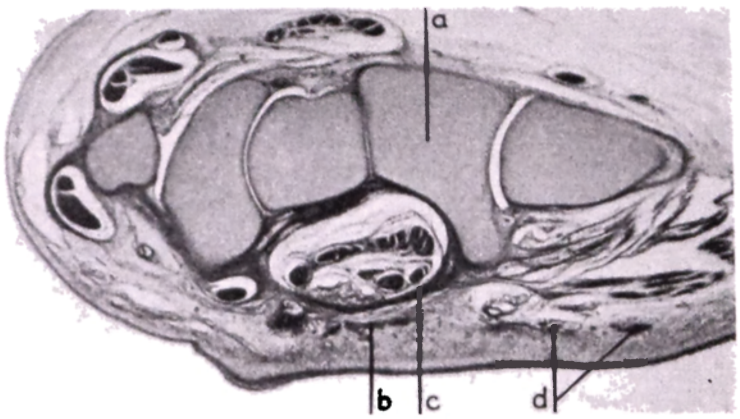

Fig. 7

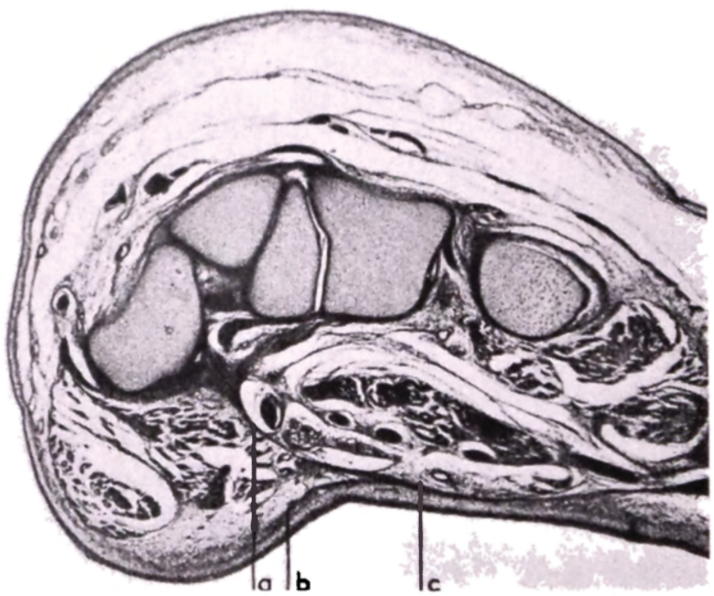

Fig. 8

Fig. 7. Transverse section of the wrist showing the transverse carpal ligament (c) forming the ventral border of the carpal canal and its relationship to the palmaris longus tendon (b) superficially to it. Palmaris brevis (d) is seen as a well defined muscle strictly limited to the hypothenar region. a — hamate. (× 20.)

Fig. 8. Transverse section of the carpalmetacarpal region. The palmar aponeurosis (c) appears as a broad plaque, from which a thinner sheath (b) extends towards the thenar eminence. Note the well defined septum (a) separating the thenar muscles from the flexor tunnel. (× 20.)

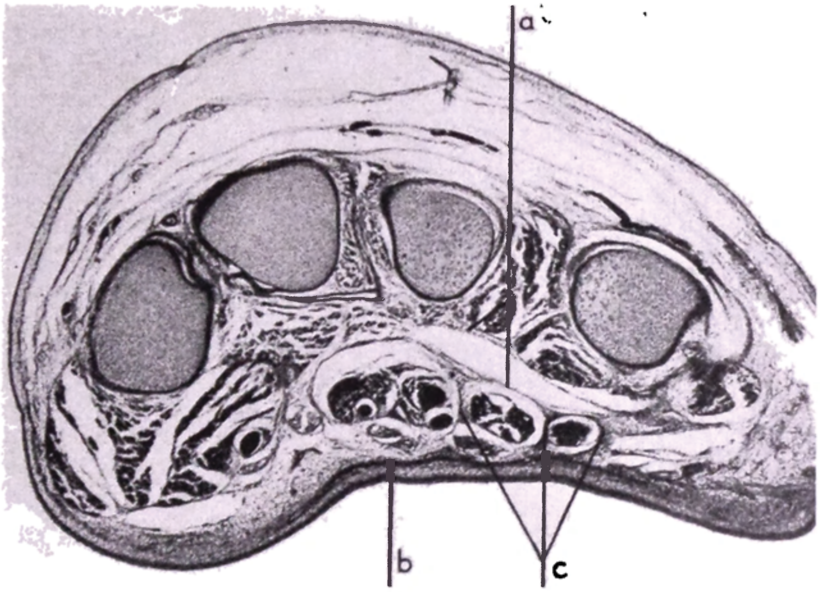

Fig. 9

Fig. 9. Section across distal part of palm. The palmar aponeurosis (b) is well developed. To the ulnar side are seen septa (c) uniting the aponeurosis with the deep palmar fascia (a). (× 20.)

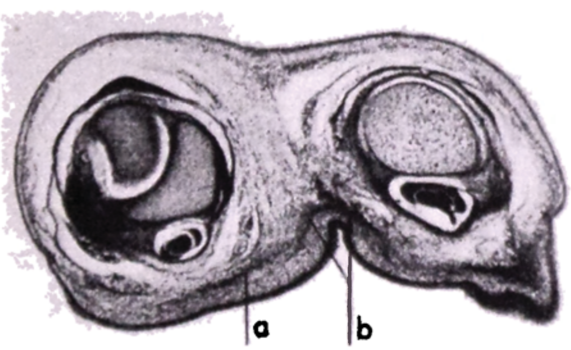

Fig. 10

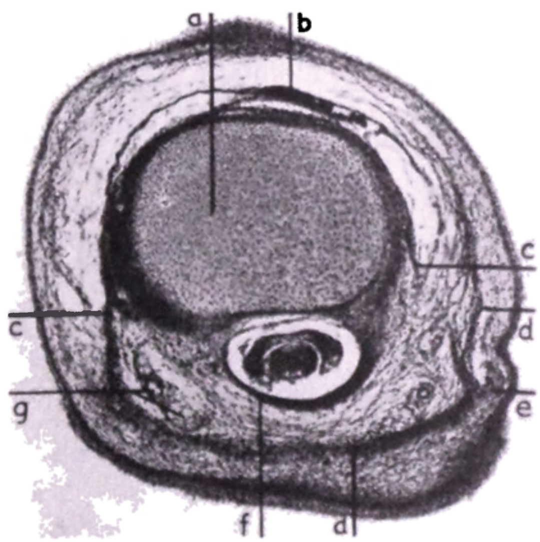

Fig. 11

Fig. 10. Transverse section just proximal to the web of the index and middle fingers. The natatory ligament (b) is well demonstrated. To the left it joins the digital extension of the palmar aponeurosis (a). (× 20.)

Fig. 11. Transverse section near base of middle finger with an almost diagrammatic representation of the arrangement of the digital fascia (d). It is strengthened by the digital extension of the palmar aponeurosis on the volar aspect and by fibres to the lateral septa (c). The latter are attached to the sides of the phalanx and to the expansion of the extensor tendon. On the deep side of the digital nerve and artery (g) there is a thin fibrous layer. (× 35.) Cf. Fig. 4.

a — proximal phalanx; e — fibres to the skin; f — vaginal ligament enclosing the flexor tendons.

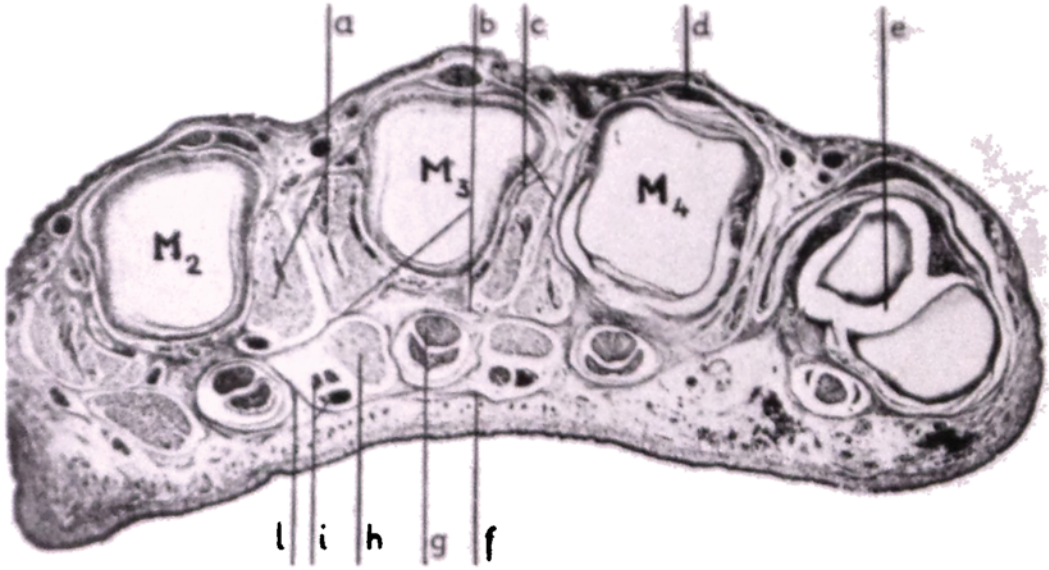

Fig. 12. Transverse section across distal part of palm in a human foetus at the 16 cm stage. Photomicrograph. (× 10.)
a — interosseous muscles; b — deep palmar fascia; c — penetrating fibres to the dorsum of the hand; d — extensor tendon; e — 5th metacarpophalangeal joint; f — palmar aponeurosis; g — flexor tendons; h — lumbrical muscle; i — digital nerve and artery; l — paratendinous septum.

schematic picture of the connective tissue framework of the palm, described previously in the fully-developed stage.

During the whole course of development the palmar aponeurosis consisted of homogeneous tissue similar to that forming tendon tissue. An increasing number of fibrillar elements appeared successively. No localized differentiations or regions reminiscent of muscle tissue were observed in preparations stained with haematoxylin-eosin or impregnated with silver.

The investigation thus supported neither FERRARINI's assertion that the palmar aponeurosis in the embryonic stage does not extend distal to the metacarpophalangeal joints, nor GRÄFENBERG's opinion regarding its connexion with the palmaris brevis muscle.

Functionally and anatomically the palmar aponeurosis in the adult stage certainly forms a homogeneous structure but its morphogenesis shows that it develops from different primordia. The significance of this fact as well as other conclusions from embryological observations will be discussed in the chapter on the aetiology of Dupuytren's contraction (p. 134).