

Cadaveric study of the long extensor tendons of the finger over the dorsum of the hand

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SUMMARY

The extensor tendons to the fingers were studied in dissections of 120 hands from 60 fresh cadavers, and the divisions of the tendons, as well as the intertendinous connection, were analyzed. One tendon of the extensor digitorum communis (EDC) was present for the second finger in 88.33% of cases, one for the third finger in 55.8%, two for the fourth finger in 48.33%, and the absence of the extensor digitorum communis tendon to the fifth finger was noted in 26.66% of cases. The extensor indicis had only one tendon for the second finger in 96.66%, two tendons in 0.83% and absent in 2.5% cases. The extensor digiti minimi (EDM) to fifth finger was present in 75.83%, while in 23.33% of the hands two tendons were present. Only one hand (0.83%) lacked the EDM. The most common intertendinous connections were seen between the EDC tendons of the fourth and third fingers in 96.66% cases. Surgeons must be familiar with these variations when performing tendon transfers for the correction of injury, paralytic defects or the treatment of tendon ruptures in rheumatoid arthritis, particularly those involving the use of the extensor indicis and the extensor digiti minimi. The symmetric study in both hands revealed the existence of individual variations and the pattern observed

in one hand is not necessarily the same in the other hand.

Key words: Anatomical variations – Wrist and hand – Cadaver – Extensor tendons

INTRODUCTION

The dorsum of the hand demonstrates greater anatomic variability because of tendinous multiplicity and the presence of connections between the different tendons. In most cases, there is more than one tendon for each finger between the wrist and the MCP joints (Mestdagh et al., 1985). Furthermore, this multiplicity increases near the ulnar zone (Von Schroeder et al., 1995; El-Badawi et al., 1995; Gruber, 1885). The most frequent distribution pattern reported in literature is a single extensor indicis tendon located ulnar to the extensor digitorum communis tendon of the second finger, a single extensor digitorum communis tendon for the second finger; a single thick extensor digitorum communis tendon for the third finger; a double extensor digitorum communis tendon for the fourth finger; no extensor digitorum communis tendon for the fifth finger; and a double extensor digiti minimi tendon for the fifth finger (Standring, 2005; Sinnatamby, 2001).

The most frequent variation is double extensor indicis tendon, a double or triple extensor digitorum tendon for the third finger, a single or triple extensor digitorum tendon for the fourth finger, and a single or double extensor digitorum tendon for the fifth finger (El-Badawi et al., 1995; Von Schroeder et al., 1995; Gonzales et al., 1996).

This information is of clinical importance in cases of hand trauma and disease requiring tendon repair or transfer. Thus, the aim of his study was to determine the different patterns of extensor tendons on the dorsum of hand in an Indian population.

MATERIAL AND METHODS

This study was carried out at the plastic surgery unit of the Department of Surgery and Forensic Medicine, NSCB Medical College, Jabalpur, on 120 hands from 60 fresh cadavers over a period of 1 year. These hands were obtained from fresh cadavers referred for post mortem. The study determines the number of tendons emerging at the distal edge of the extensor retinaculum, identifying the muscle of origin and the finger of destination. Dissection was carried out from the extensor retinaculum to the metacarpo-phalangeal joint of the fingers to distinguish between the tendons of the extensor digitorum communis and those of the extensor indicis and extensor digiti minimi. A flap of skin and superficial fascia was raised on the back of each hand, and the extensor retinaculum was divided longitu-

dinally to fully expose the tendons, intertendinous fascia and intertendinous connections. Tendons at the extensor retinaculum were followed proximally up to their muscle of origin and distally up to their destination finger. The number of tendons and their relations were noted but the morphology of intertendinous connection was not detailed. Cadavers with congenital anomalies of the hand and healed scars or lacerations on the dorsum of the hand were excluded from the study. Details were noted and photographs were taken.

RESULTS

A study of 120 hands by dissection, observation and photography revealed following arrangements of extensor tendons on dorsum of hand.

Extensor Digitorum Communis (EDC) – (Table 1)

Distribution to fifth finger – 18.33% (22 hands) of hands had one common tendon, which bifurcated near the heads of the 4th/5th metacarpals to join the extensor expansions of the fifth and fourth fingers. 51.66% (62 hands) of hands had a single independent tendon from the EDC to the fifth finger, and in 26.66% (32 hands) of hands there was no tendon to the fifth finger (Fig. 1). Two tendons for the fifth finger were seen in three hands (2.5%) and three tendons in one hand (0.83%).

Distribution to fourth and third finger – The EDC muscle contributed one tendon to the fourth finger in 30% (36 hands); two tendons in 48.33% (58 hands), while three tendons

Fig. 1. Dorsal view of left hand. No extensor digitorum communis (EDC) tendon to the fifth finger is present; two extensor digiti minimi (EDM) tendons.

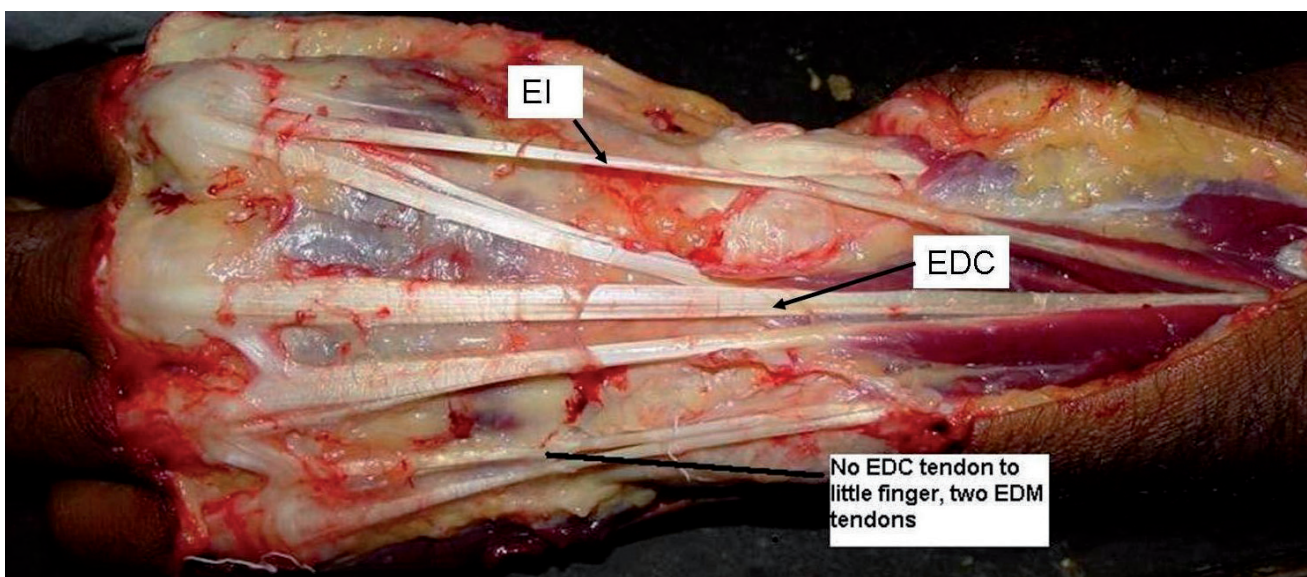


Table 1. Distribution of the extensor digitorum communis over the dorsum of the hand.

Number of tendons	Extensor Digitorum Communis (Total: 120 hands)			
	Little finger	Ring finger	Middle finger	Index finger
No tendon	32	0	0	1
One common to ring/little finger	22	-	-	-
One tendon	62	36	64	106
Two tendons	3	58	39	12
Three tendons	1	24	16	1
Four tendons	0	2	1	0

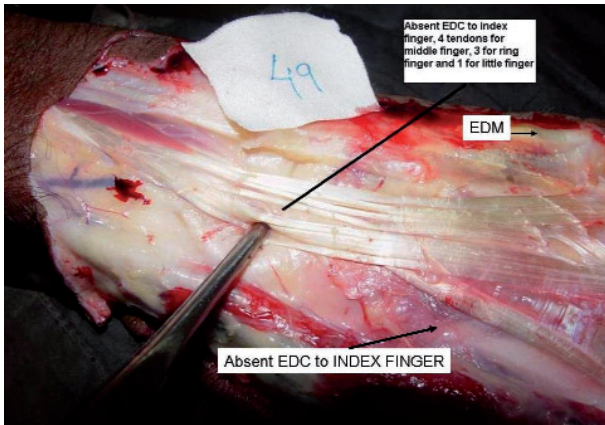


Fig. 2. Dorsal view of left hand. Absent extensor digitorum communis (EDC) to the second finger; 4 tendons for the third finger, 3 for the fourth finger and 1 for the fifth finger.

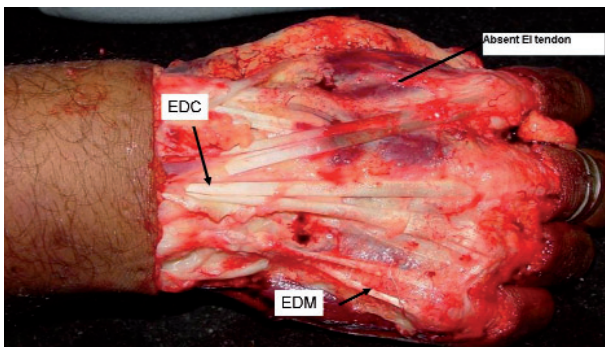


Fig. 3. Dorsal view of right hand. Absent extensor indicis (EI) tendon.

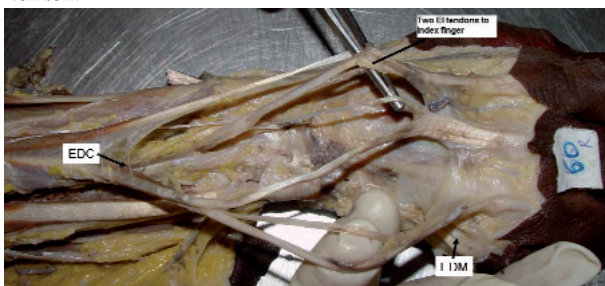


Fig. 4. Dorsal view of right hand. Two extensor indicis (EI) tendons to the second finger.

were seen in 20% (24 hands) cases and four tendons were found in 1.66 % (2 hands) of cases. In 55.8% (67 hands) there was only 1 tendon from the EDC to the third finger. Two, three and four tendons to this finger occurred in 27.5% (33 hands) 13.3 % (16 hands) and 3.3% (4 hands) respectively.

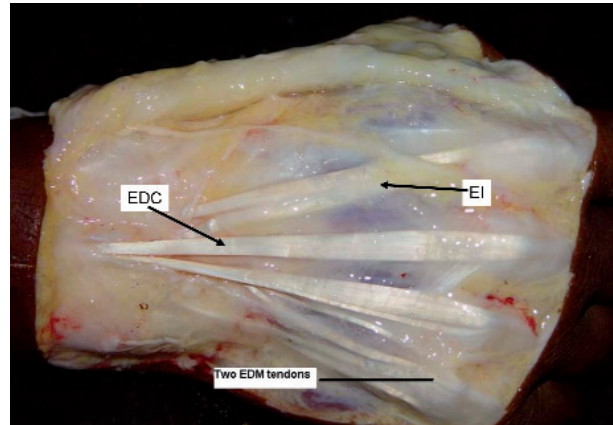


Fig. 5. Dorsal view of right hand. Two extensor digiti minimi (EDM) tendons.

Distribution to second finger – There was only one tendon from the EDC to the second finger in 88.33% (106 hands) and two tendons in 10% (12 hands) of cases, while three tendons were present in one hand (0.83%) and a tendon was absent in one hand (0.83%, Fig. 2).

Extensor Indicis (EI)

The vast majority of cases had only one tendon for the second finger, 96.66% (116 hands); two tendons were observed in one hand (0.83%), and the absence of EI was noted in three hands (2.5%, Figs. 3, 4). All EI tendons to the second finger were positioned on the ulnar side of the EDC tendon.

Extensor Digiti Minimi (EDM)

In 75.83% (91 hands), one tendon was observed distal to the retinaculum, while in 23.33% (28 hands) of the hands two tendons to the fifth finger were present (Fig. 5). Only one hand (0.83%) showed the absence of an EDM (Fig. 6).

Intertendinous Connections (ITC)

The most common ITCs were seen between the EDC tendons of the fourth and third fingers 96.66% (116 hands). The third and second finger tendons had similar connections in only 18.33% (22 hands) of cases. The inter-

Table 2. Distribution of extensor tendons on the right and left hands.

Digits	Left Hand (N = 60)					Right Hand (N = 60)					
	Absent	Single	Double	Triple	Four	Absent	Single	Double	Triple	Four	
EI	1	59	0	0	0	2	57	1	0	0	
EDC	IF	1	51	7	1	0	55	5	0	0	
	MF	0	30	18	11	1	34	21	5	0	
	RF	0	19	25	16	0	17	33	8	2	
	LF	15	45	0	0	0	17	39	3	1	0
EDM	0	46	14	0	0	1	45	14	0	0	
Juncturae Web space	II	9					13				
	III	57					59				
	IV	53					52				

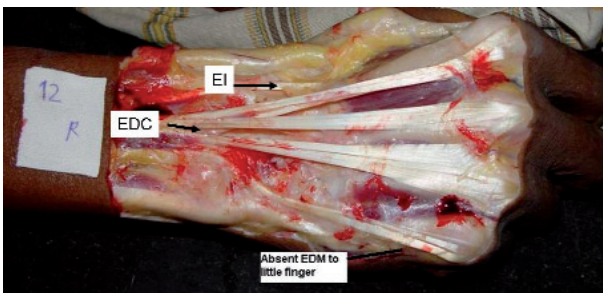


Fig. 6. Dorsal view of right hand. Absent extensor digiti minimi (EDM) to the fifth finger.

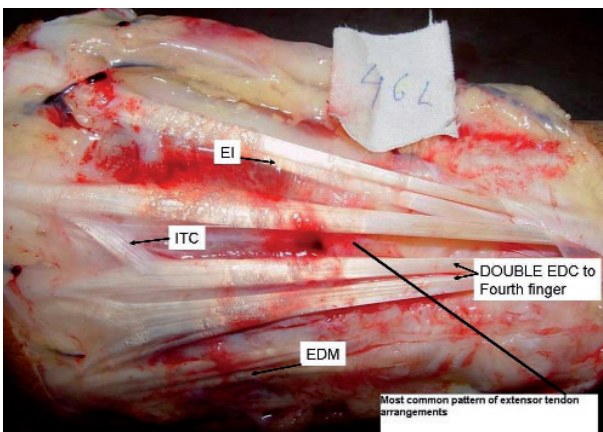


Fig. 7. Dorsal view of left hand. Most common pattern of extensor tendon arrangements..

tendinous connections between the tendon of the fourth finger and fifth finger were present in 87.5% (105 hands) of cases.

The side-wise distributions of extensor tendons are shown in Table 2. Study of both sides of the hands revealed the existence of variations, and the pattern observed for one hand was not necessarily the same for the other hand.

Most common pattern of extensor tendons

EDC tendons displayed a single tendon to the second finger, a single one to the third finger and a single one to the fifth finger, while a double tendon to the fourth finger was noted. The EI and EDM tendon shows a single tendon towards their respective fingers. The pres-

ence of an intertendinous connection was most commonly found in the third and fourth intermetacarpal space (Fig. 7).

DISCUSSION

Many authors have studied the divisions of extensor tendons. Le Double (1897) was the first to describe the result of his own and other anatomical studies. However, these studies were not precise and were not accompanied by images. Tountas and Bergmann (1993) compiled the results of most studies and provided illustrations. The more recent studies include those performed by Mestdagh et al. (1985), von Schroeder et al. (1995), El-Badawi et al. (1995), Gonzales et al. (1996), Schenck (1964), Godwin et al. (1992) and Hirai et al. (2001). The comparison of variations in extensor tendons of different studies by other authors is given in Table 3.

Variations in the Extensor Digitorum Communis - In our study, we noted the presence of one tendon for the second finger in 88.33% of cases (97% according to Gonzales, 1996); one for the third finger in 55.8%; two for the fourth finger in 48.33%; a common tendon for the fourth and fifth fingers in 18% of cases, and the absence of the extensor digitorum communis tendon to the fifth finger in 26.66% of cases (56% according to Schenck, 1964; 60% according to Zilber and Oberlin, 2004; and 30% according to González, 1996). None of the studies reported the absence of a EDC tendon to second, third and fourth fingers. Von Schroeder and Botte (1995) described the presence of one tendon for the second finger in 98% cases; one for the third finger in 51% of cases; two for the fourth finger in 63% of cases, and none for the fifth finger in 54% of cases.

Table 3. The ED, EI and EDM tendons compared with previously published data.

Digits / No. of tendons	Zilber & Oberlin (50 hands) %	Hirai et al. (548 hands)%	Godwin & Ellis (50 hands)%	El-Badawi et al. (181 hands)%	Von Schroeder & Botte (43 hands)%	Mestdagh et al. (150 hands)%	Present Study (120 hands)%
A. EDC tendons							
1. Fifth finger							
No Tendon	60	16	2	29	54	1	26.66
One tendon	32	25	2	30	19	6	51.66
Two tendons	6	10	0	0	25	0	2.5
Three tendons	2	1	0	0	2	0	0.83
One common to ring/little finger	0	48	96	41		93	18.33
2. Fourth finger							
One tendon	18	33	96	62	12	63	30.00
Two tendons	52	49	2	37	63	31	48.33
Three tendons	22	14	2	1	16	6	20.00
Four tendons	8	4	0	0	9	0	1.66
3. Third finger							
One tendon	64	54	92	63	51	61	55.83
Two tendons	24	39	4	18	28	39	27.5
Three tendons	8	7	4	19	16	0	13.33
Four tendons	4	0	0	0	5	0	3.33
4. Second finger							
No tendon	0	0	0	0	0	0	0.83
One tendon	100	92	100	100	98	95	88.33
Two tendons	0	8	0	0	2	5	10
Three tendons	0	0	0	0	0	0	0.83
B. EI tendons							
Absent	4	0	0	1	0	1	2.5
One tendon	78	86	92	90	77	93	96.66
Two tendons	18	14	8	5	16	6	0.83
Three tendons	0	0	0	4	7	0	0
C. EDM tendons							
No tendon	0	0	0	0	0	0	0.83
One tendon	28	10	0	35	2	16	75.88
Two tendons	70	87	82	63	84	77	23.33
Three tendons	2	3	8	2	7	7	0
Four tendons	0	0	10	0	7	0	0
Intertendinous connections							
II	82	69	80	36.5			18.33
III	98	97	70	74.6			96.66
IV	100	56	30	28.7			87.5

According to El-Badawi (1995) in 30% of the hands there was a single independent tendon from the EDC to the fifth finger; one tendon to the fourth finger in 62% of cases; two tendons in 37%, while three tendons were seen very rarely. In the majority of cases (63%) there was only one tendon from the EDC to the third finger. Von Schroeder and Botte (1995) described

that in general there is favorable agreement between studies, and the differences may be largely due to differences in definition because longitudinal fissures in EDC tendons are present but tendon slips were not clearly defined. In contrast, tendons that could be readily divisible along fissures without sharp dissection were defined as tendon slips and therefore

yielded higher numbers for multiplicity. Another reason for multiplicity is the juncturae from the EDC-fourth to the fifth finger may be mistakenly defined as the EDC-fifth. We found that absence of the EDC-fifth was associated with a double EDC-fourth and a thick type-3 juncturae that substituted for the absent EDC-fifth finger tendon.

Le Double (1897) described the segmentation of EDC as five to 12 tendons and some time founded the absence of a tendon to the second finger. The EDC tendon to the fifth finger is often replaced by an aponeurotic expansion between the tendon of the fourth finger and EDM, known as the slip of Testut (1884). It is defined as fibrous bands passing obliquely between the diverging tendons of the extensor digitorum on the dorsum of the hand. To differentiate it from the tendon, tracing this proximally and distally it will not have a proximal muscle origin and distal extensor expansion as an insertion. The assimilation of this tendinous expansion (the tendinous slip of Testut) as a tendon or as an intertendinous connection could explain the differences in the results reported by the different authors with respect to the tendons of the extensor digitorum communis for the fourth and fifth fingers.

Variations in the Extensor Indicis - In our dissections, we observed vast majority of cases had only one tendon for the second finger 97% (116 hands); two tendons in one hand and absent EI in three hands. All EI tendons to the second finger were positioned ulnar to the EDC tendon. EI absence was also noted by Mestdagh (1985) and El-Badawi (1995) in 1% of their cases. Le Double (1897) noted absence of EI and the presence of tendon for third finger arising from EI, which Wood (1868) called the extensor medii digiti (extensor medii proprius). The extensor medii proprius is a muscle analogous to the extensor indicis and has a similar origin, but inserts into the third finger (Von Schroeder and Botte, 1991). The extensor indicis et medii communis muscle is an extensor indicis muscle that split and insert into both the second and third fingers. The incidence of extensor medii proprius reported by different authors includes 8% (Wood, 1868), 13% (Wagenseil, 1936), 9.15% (Straus, 1941) and 10.3-12% according to von Schroeder and Botte (1991). Tountas and Bergmann (1993) observed that EI could be absent or duplicated and could

provide a tendon to the thumb, the fourth finger or more often to the third finger.

Godwin (1992) found single EI in 46 hands (92%), double in 4 (8%). In one of the hands in which EI tendon was double and radial to the second finger's ED tendon, it was also connected to EPL tendon.

Variations in the Extensor Digiti Minimi - Le Double (1897) observed an absent EDM with tendon to the fifth finger arising either from the EDC or ECU. Zilber and Oberlin (2004) observed a tendon arising from the ECU in 6% of cases. The EDM exhibited four tendons: two for the fifth finger and one each for the fourth and third fingers. Sometimes EDM gave three tendons: two for the fifth finger and one for the fourth finger (Seradge et al., 1999). In our study in 23.33% of the hands, two tendons were observed distal to the retinaculum, while 75.88% of the specimens remained with one tendon on the dorsum of the hand. Only one hand presented with the absence of the EDM. Two EDM tendons were present in a relatively low percentage of our cases as compared to the series of El-Badawi (1995) (63%) and Hirai et al. (2001) (87%). However, a single tendon for this muscle was observed in a higher percentage in our study than those reported by Schenck (1964), El-Badawi, (1995) and Mestdagh (1985). Godwin and Ellis (1992) did not observe any EDM muscle with a single tendon. On the other hand, none of our cases had four tendons for this muscle.

Variations in the Intertendinous Connections - We found intertendinous connections in the second inter-metacarpal space (18.33%), third inter-metacarpal space (96.66%) and fourth inter-metacarpal space (87.5%). Godwin et al. (1992) reported the presence of intertendinous connections, 80%, 70% and 30%, respectively (82%, 98% and 100% respectively by Zilber and Oberlin, 2004). Hirai et al. (2001) reported a 69%, 97% and 56% respectively. We noted that, in three hands without an extensor indicis, the extensor digitorum communis tendon to the second finger lacked an intertendinous connection.

If there is no extensor digitorum communis tendon to the fifth finger, the vast majority of hands have an intertendinous connection, connecting the common extensor tendon of the fourth finger to the extensor aponeurosis of the little finger. On the other hand, if, there is

a relatively large extensor digitorum communis tendon to the fifth finger, the intertendinous connection is likely to be absent. The fourth finger is the least independent and typically has an oblique intertendinous connection originating from its EDC tendon that runs in a direction opposite to the pull of the EDC tendon and therefore inhibits the extension of the fourth finger if the adjacent tendons are flexed. The acute angles of insertion of the intertendinous connection into the extensor tendons of the third and fifth fingers allow for greater mobility of these digits since the direction of insertion is in the same direction as the pull of the tendon. The second finger is the most mobile for two reasons. First, it receives an EI tendon, which does not have an intertendinous connection. Second, the intertendinous connection to the EDC tendons of the second finger may be absent, and when present, is quite thin and usually transverse to the tendon, thus allowing for greater laxity and mobility yet at the same time allowing for the different functions attributed to the intertendinous connection.

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