

STUDY OF VARIATIONS IN THE EXTENSOR TENDONS OF FORE-ARM AND HAND

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ABSTRACT

Study of extensor tendons in forearm, dorsum of hand and their intertendinous connections was conducted in 70 upper limbs (35 right and 35 left) from Govt. Thoothukudi Medical College, Tamilnadu, India. Variations in the extensor tendons of fingers, both proximal and distal to the extensor retinaculum were analyzed. The arrangement of extensor pollicis longus and brevis tendons were traced up to base of proximal phalanx and extensor expansion at the level of proximal as well as base of phalanx, they were found to be single or doubled. Extensor indicis were single tendon in most of the specimens. The extensor digitorum gave off single tendon to the index finger, double tendons to the middle finger and triple tendons to the ring finger. The extensor digiti minimi often had single or double tendon to the little finger distal to extensor retinaculum, in those cases contribution from the extensor digitorum tendon slip to the little finger were absent. Three types of juncturae tendinum were identified between the tendons of extensor digitorum in the 2nd, 3rd, 4th inter metacarpal spaces of hands. The extensor indicis tendon was always observed to lack juncturae tendinum. Type I juncturae tendinum was seen in the 1st inter metacarpal space. Type II was seen in the 3rd intermetacarpal space. Type III was identified in the 4th intermetacarpal space. Knowledge of these variations may help surgeons while performing tendon repair or transfer. Surgeons should keep in mind about the existence of these variations for better diagnosis and reconstructive procedures.

KEYWORDS: Extensor Digitorum Tendon, Extensor Indicis, Extensor Digiti Minimi, Juncturae Tendinum, Variations.

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INTRODUCTION

Human hand is specialized to perform skilled movements. Hence anatomy of the extensor tendon in the dorsum of hand is important. Any variation may affect the movements of fingers. Found on the dorsum of hand are Extensor pollicis longus and brevis, Extensor digitorum (ED),

Extensor indicis (EI), Extensor digiti minimi (EDM), Extensor pollicis longus (EPL) and Extensor pollicis brevis (EPB). Extensor digitorum is otherwise called extensor digitorum communis. It is one of the superficial muscles of the forearm. The muscle belly gives rise to 4 tendons to the medial four digits. Over the proximal

phalanx, the tendon for each digit divides into 3 slips and contributes to the dorsal digital expansion. Extensor indicis muscle is a deep muscle of forearm arising from the posterior surface of ulna and interosseous membrane. It joins with tendon of ED on ulnar side for the index finger and lies in the 4th compartment within the common synovial sheath. It helps in extension of index finger and wrist.

Extensor pollicis longus and brevis arise from the posterior surface of ulna and radius respectively and also from adjoining part of interosseous membrane. They are inserted into the base of distal phalanx and proximal phalanx of thumb on the dorsum of hand respectively. Extensor digiti minimi arises from the common extensor origin from the lateral epicondyle and lies medial to the extensor digitorum (ED) tendon for the little finger and is inserted into extensor expansion.

Tendons may be single, double or triple at the myotendinous junction. Tendon slips are defined as division of tendon or splitting of tendon into 2 or more slips [1].

Juncturae tendinum (JT) is defined as band of connective tissue existing between the tendons. It prevents independent extension of digits since they bridge the tendons. It hides tendon lacerations. Von Schroeder et al classified JT into 3 types. Type 1- thinnest and filamentous band, type 2- fibrous band and type 3- tendinous band which is subdivided into r and y shaped [2].

Tendon injuries in dorsum of hand are common. The present study was performed to observe the variations of extensor tendons of fingers and their inter tendinous connections. Awareness of the variations of extensor tendon is important for surgeons in better diagnosis, tendon repair and reconstructive procedures.

MATERIALS AND METHODS

This study was conducted in 70 embalmed upper limb specimens (35 right and 35 left) obtained from adult cadavers of unknown age and sex collected from Department of Anatomy, Govt. Thoothukudi Medical College, Thoothukudi, Tamilnadu, India. After removal of skin and superficial fascia on the back of forearm the extensor retinaculum was divided longitudinally to expose the tendons. The number of tendons

of each muscle was traced proximal and distal to the extensor retinaculum (ER). Variations in their number, site of insertion and intertendinous connections present between the tendons were studied. Photographs were taken with digital camera and data were tabulated.

RESULTS

Extensor pollicis brevis: Extensor pollicis brevis was observed in all specimens. It had single tendon in 87.2% and double in 12.8% of specimens. In 60% of specimens, the tendon was attached to the base of proximal phalanx of thumb. However in 37.2% of specimens, tendon was attached to the extensor expansion of thumb at the level of base of proximal phalanx, while in 2.8 % of specimens, the EPB tendon was inserted into the extensor expansion of thumb at the level of base of distal phalanx and in 60% it was inserted to the base of proximal phalanx of thumb.

Extensor pollicis longus: Extensor pollicis longus was observed to be single in 72.9% and double in 27.1% of specimens [Fig.1]. In 85.7% EPL tendon were inserted into distal phalanx of thumb through its extensor expansion. In 14.3% of specimens it is attached to the level of base of proximal phalanx of thumb through its extensor expansion.

Extensor indicis: In 14.2% of specimen EI was absent. In 85.7% of the specimens it persisted as single tendon ulnar to the ED tendon of index finger and was inserted to extensor expansion.

Extensor digitorum: The number of tendons of ED varied from 3 to 8 [Table.1]. The distribution of these tendons to index, middle, ring and little finger is tabulated [Table.2]. Multiple slips of extensor tendons were noted [Fig.2]. In case of multiple slips of ED tendon to ring finger, the lateral one was frequently connected to ED of middle finger by intertendinous connections, the medial bifurcating tendon was inserted into extensor expansion of ring and little fingers. In most of the specimens no independent slip to little finger was observed, it is either replaced by intertendinous connections with ring finger or by bifurcating tendon to both ring and little finger. Ultimately these slips and their variations were inserted into the extensor expansion

of the little finger.

Extensor digiti minimi: In 97.1% of specimens single tendon was noticed proximal to extensor retinaculum. Distal to ER, the tendon persisted as single in 45.7% and doubled in 54.3% of specimens [Table.1] [Fig.3]. Proximal to ER, it was single in 97.1% and doubled in 2.9% of specimens which were finally inserted into the extensor expansion of the little finger.

Juncturae tendinum: JT were recorded between the adjacent tendon of ED in 2nd, 3rd and 4th inter metacarpal spaces (IMCS). In the II IMCS, JT was absent in 35.7% and type I JT was noticed in 64.3%. In 3rd IMCS, type I JT was present in 40%, type II JT was present in 18.6%, type 3r JT was observed in 31.4% and type 3 y JT was noticed in 10%. In 4th IMCS, type I JT in 20%, type II JT in 11.4%, type 3r JT in 22.9% and type 3 y JT in 45.7% were present [Fig.4].

Fig. 1: Right hand of dorsum of hand showing double tendon of extensor pollicis longus (EPL1 and EPL 2) and single tendon of extensor pollicis brevis (EPB).



Fig. 2: Right hand. Absent Extensor indicis (EI), ED1, ED2, ED3, ED4, ED5&ED6 - Tendons of extensor digitorum distal to extensor retinaculum. ED4.1, ED4.2, ED4.3, ED6.1, ED6.2-splitting of tendons.

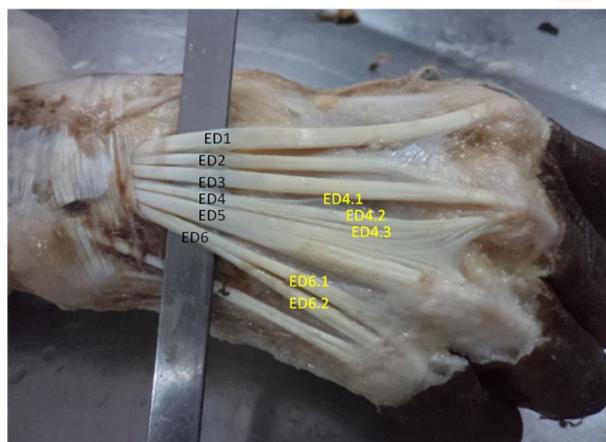


Fig.3: Little finger receiving 4 tendons. ED-L (1 &2) - Extensor digitorum tendons to little finger. EDM- divided into 2 tendon slips.

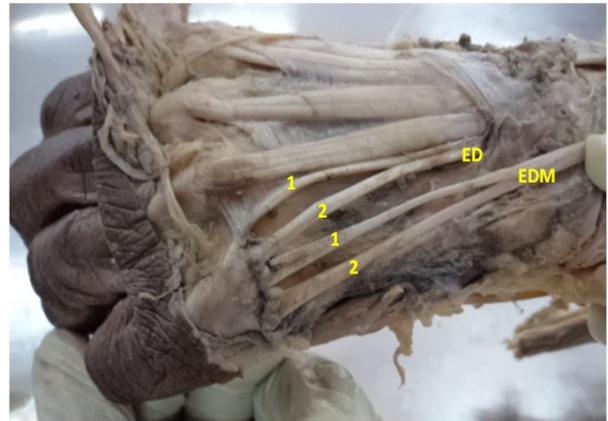


Fig.4: Juncturae Tendinum. JT1- Type 1 in 2nd IMCS, JT2- Type 2 in 3rd IMCS, JT3r- Type 3 in 4th IMCS.

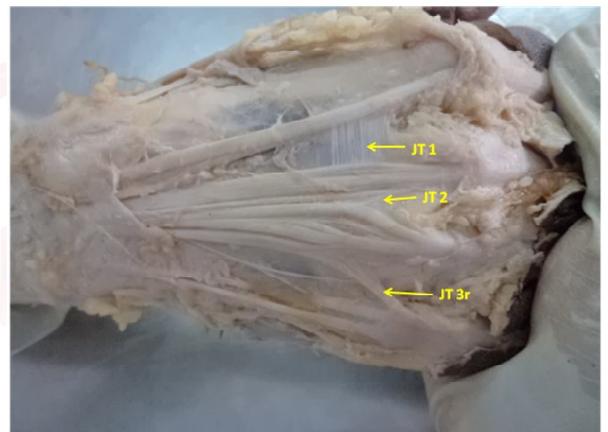


Table 1: Number of tendons of extensor digitorum and extensor digiti minimi in forearm and hand.

Muscle	Number of tendons	Proximal to extensor retinaculum	Distal to extensor retinaculum
Extensor digitorum	Three	32.80%	24.20%
	Four	47.10%	28.50%
	Five	14.20%	24.20%
	Six	5.70%	21.42%
	Seven	0	0
	Eight	0	1.40%
Extensor digiti minimi	One	97.10%	45.70%
	Two	2.90%	54.30%

Table 2: Arrangement of extensor digitorum tendons in the hand.

Number of tendons	Index finger			Middle finger			Ring finger			Little finger		
	Right (%)	Left (%)	Total (%)	Right (%)	Left (%)	Total (%)	Right (%)	Left (%)	Total (%)	Right (%)	Left (%)	Total (%)
Absent	-	-	-	-	-	-	-	-	-	62.9	51.4	57.1
One	91.4	97.1	94.3	57.1	60	58.6	31.4	48.6	40	20	31.4	25.7
Two	8.6	2.9	5.7	20	31.4	25.7	28.6	11.4	20	11.4	22.9	17.1
Three	-	-	-	14.3	17.1	15.7	25.7	42.9	34.3	-	-	-
Four	-	-	-	-	-	-	2.9	8.6	5.7	-	-	-

Table 3: Distribution of tendons of extensor digitorum given by various authors.

Author	Index Finger No. of Tendons %				Middle Finger No. of Tendons %				Ring Finger No. of Tendons %				little Finger No. of Tendons %				
	1	2	3	4	1	2	3	4	1	2	3	4	0	1	2	3	4
Abdel-Hamed G A et al[4]	96.8	3.2	-	-	41.1	46.3	12.6	-	6.3	36.8	50.5	6.3	85.3	14.7	-	-	-
Yamine K[22]	98	1.8	0.2	-	67.7	24.2	6	0.42	58.6	29.1	7.1	1.3	-	58.5	10.4	0.94	25
Prameela Dass et al[1]	100				93	7			69	27	4		66				
Present Study	94.3	5.7	-	-	58.6	25.7	15.7	-	40	20	34.3	5.7	57.1	25.7	17.14	-	-

Table 4: Type of juncturae tendinum (JT) in the 2nd, 3rd and 4th intermetacarpal space.

Author	2 nd IMCS (Type of JT) %					3 rd IMCS (Type of JT) %				4 th IMCS (Type of JT) %			
	Absent	1	2	3r	3y	1	2	3r	3y	1	2	3r	3y
Prameela Dass et al[1]	13	81	4	-	-	9	67	8	16	1	15	73	11
Pinar Y et al[23]		57.4	3.7	-	-	16.7	59.3	5.55	14.8	-	-	37	53.7
Von Schroeder HP et al[2]	12	88	-	-	-	28	40	33		-	23	80	
Present study	35.7	64.3	-	-	-	40	18.6	31.4	10	20	11.4	22.9	45.7

DISCUSSION

Tendon repair surgeries are in increasing trend because of increase in trauma. Study on variations of extensor tendons is of utmost important as it will guide in tendon graft surgeries.

Extensor pollicis brevis (EPB) is sometimes absent or being fused with abductor pollicis longus. Its tendon is often united with that of the long extensors and is inserted with it or it may be continued as an independent slip to the base of the distal phalanx [3]. Abdel-Hamid GA et al reported that EPB was absent in 2.1% and it had single tendon in 87.4% and duplicated tendons in 10.5% of specimens [4]. In the present study, EPB was found in all specimens but was double in 12.8%.

The insertion of EPB as reported by Abdel-Hamid GA [4] was 55.8% at the base of proximal phalanx of thumb which is slightly lower than the present study. 41% to the extensor expansion at the level of base of proximal phalanx and in 3.2% it was inserted into extensor expansion at the level of base of distal phalanx which is slightly higher than the present study.

EPL was found in the third compartment of extensor retinaculum in all specimens but Nayak S R et al [3] reported a case in which EPL was found along with ECRL and brevis in second compartment.

Ferreira AH [5] stated that EPL existed as single tendon in all specimens and it was attached to extensor expansion of thumb at level of base of proximal phalanx but in the present study it was single only in 72.8% and doubled in 27.1% of specimens.

Joshi, S.S. [6] reported the insertion of EPL to both phalanges of thumb only in 1.8% in left side and none in right side. It was inserted into distal phalanx in 96.4% of right side and 100% in left side. It was inserted into proximal phalanx in 3.6% of right side%. In the present study, in 85.7% EPL tendon were inserted into distal phalanx of thumb through its extensor expansion and in 14.3% of specimens it is attached to the level of base of proximal phalanx of thumb through its extensor expansion. In 90% of cases reported EI had only one tendon for the index finger (7). Satya Prasad Venugopal [8] reported 2 tendons of EI bilaterally. Extensor indicis was absent in both hands of one cadaver was reported by Zilber & Oberlin [9]. Extensor indicis permit independent extension of index finger and in most commonly used in tendon transfer [10].

The most common pattern seen with Extensor digitorum (ED) was 3 tendons proximal and 5 tendons distal to the extensor retinaculum (ER). el-Badawi et al reported 2 to 6 ED tendon and 3 to 8 tendons proximal & distal to the extensor retinaculum respectively [11]. In our study, the number ED tendons varied from 3 to 6 proximally and 3 to 7 distal to extensor retinaculum (ER).

The tendon of ED to the digits exhibits multiple variations in their number as reported by various authors [Table.3]. It may be doubled or tripled and more commonly seen in index or middle finger. Zilber & Oberlin [9] stated that the extensor digitorum communis provided one tendon to the index finger, one to the middle finger, two to the ring finger, and none to the little finger.

Celik S et al [12] reported single tendon of ED to index finger in 100% of specimens. Palatty [13] reported that the ED to index finger was absent in 2%, single in 90% double and triple together in 8%.

ED to middle finger studied by Palatty [13] found that it was single in 72%, double and triple together in 26%, multiple tendons in 2%. Celik S et al [12] reported single tendon to middle finger in 92.6%. Contrary to this in our study, ED to middle finger existed singly in 58.6%, double tendon in 25.7% and triple tendons in 15.7% specimen.

Palatty [13] observed ED to ring finger had single tendon in 44%, double and triple together in 44% and multiple tendons in 12%. Celik S et al [12] noticed single tendon to ring finger in 75.9%.

Tanaka T et al [14] stated that 61% of ED to little finger had single slip and no slip in 24%. the ED contribution to little finger were found to be independent tendon in 42% while in 34% of specimen it was found to have a ED slip which branch to both ring and little finger. Palatty [13] stated that the tendon to little finger was single in 22%, double in 20% and absent in 58%. Celik S et al [12] stated that ED has single tendon to little finger in 24.1% and absent in 68.5%.

Gonzalez MH et al [15] had reported that in a study of fifty hands three hands lacked both extensor digitorum communis and juncturae.

Mehta V et al [16] reported a case with Extensor digitorum contributing tendons only to the middle and ring fingers, with juncturae tendinum between the extensor digitorum for the ring finger and extensor digiti minimi.

Melo C [17] reported a case in which one tendon of EDM joined the extensor pollicis longus. Palatty [13] reported that EDM was absent in 2%, single in 18%, double in 70% and triple in 10%. In the present study it was present in all the specimens, but was single in 45.7% and doubled in 54.3% of specimens. A tendon slip from the extensor digiti minimi to the ring finger was observed in one hand was reported by Zilber & Oberlin [9]. Mehta V et al [16] reported that a case of accessory tendon of EDM merging proximally with extensor carpi ulnaris. Celik S et al observed double EDM tendon in 88.9%. Govsa et al [18] stated that the most frequent

pattern of extensor tendons in the 4th IMCS was two tendons from EDM (68.5%). EDM with 3 tendinous slips, two slips to little finger and one to ring finger was reported by Seradge H et al [19].

An accessory muscle extensor medius propius was reported by Swathi Tiwari et al [20] and P.Dass [1]. No such accessory muscle was observed in the present study.

Juncturae tendinum (JT) may coordinate the extension of hand, stabilize and redistributes weight to the metacarpophalangeal joint. The types of JT were reported by many authors [Table.4]. Celik S et al [12] reported thickest type of JT between ring and little finger in 90% of specimens. Govsa et al [18] stated that the thickest type of intertendinous connection in 4th IMCS was seen in 90% of specimens and also the 4th IMCS tendons have greatest tendon length and therefore it is a suitable donor graft tissue for local tendon repair. Hirai Y et al [21] reported that the most common pattern of JT in 2nd, 3rd and 4th IMCS were type I, type 3r and type 3y respectively. Von Schroeder HP et al stated that JT was absent in all specimens in 1st IMCS.

Anatomical knowledge of variations in extensor tendons is of vital importance in various levels of dorsum of hand. Accessory tendons if present can be utilized for tendon graft rather than utilizing tendons from distant site. It is advisable to do Routine assessment of number of extensor tendons and its variations by radiological methods proceeding with tendon graft surgeries.

CONCLUSION

Presence of variation of tendons in the dorsum of hand is useful for surgeons while doing hand surgeries, such as tendon transfer and reconstructive procedures. Precise knowledge and awareness of variation is most useful for the clinicians to enable better diagnosis and treatment and may help in identification and repair of these structures. Sound knowledge of variants and their prevalence is paramount for surgeon in assessing & treating hand injuries & disorders.

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ABBREVIATIONS

EPL - Extensor pollicis longus
EPB - Extensor pollicis brevis,
ED - Extensor digitorum
EI - Extensor indicis
EDM - Extensor digiti minimi
JT - Juncturae tendinum
ER - Extensor retinaculum
IMCS - Inter metacarpal spaces

Conflicts of Interests: None

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