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Original Research Article

A Cadaveric Study on the Anomalous Extensors of the Hand

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ABSTRACT

Background: The hands play a pivotal role in skilled movements. Anomalous muscles of the extensors of the hand are seen usually in anatomical dissections and during surgeries. Variations of the muscles in the dorsum of hand may be asymptomatic or may cause dorsal wrist pain, particularly if a muscle belly encroaches on and obstruct the wrist's small extensor compartments deep to extensor retinaculum.

Methods: A total of 54 upper limb specimens were used for the current study from the Anatomy Department of an undergraduate & postgraduate teaching Medical College in India. Incidence of additional muscle belly and its tendon in the posterior compartment of the forearm and dorsum of the hand were noted and photographed.

Results: The anomalous muscle bellies and tendons in extensor compartment of forearm and dorsum of hand were observed in 10 limbs (18.5%) of 54 limbs. Of which, the extensor medii proprius (EMP) was 9.3%, extensor digitorum brevis manus (EDBM) was 3.7%. The numbers of the tendon of the extensor digitorum (ED) were varied in 3 limbs (5.6%).

Conclusion: Knowledge of anatomical data of such variant muscles and additional belly or tendon in the extensor compartment of forearm and dorsum of hand is essential for surgeons to modify treatment plan, so as to avoid reporting error and of surgical procedures while operating on hand.

KEY WORDS: Hand extensors, Anomalous muscles, Extensor mediiproprius, Extensor digitorum brevis manus, Extensor digitorum

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INTRODUCTION

The hands are important part of upper limb and it plays a pivotal role in skilled movements for manual dexterity in professional labour and recreational activities. The arrangement of muscles in the extensors of hand is varied and its variations are commonly identified during surgical procedures and cadaveric dissections during teaching. Unusual variations of muscles and tendons of extensors of hand may be asymptomatic or it may lead to restrictions in movements of the hand.

Literature has reported the presence of multiple variations in extensor of the hand muscles and tendons. The various types of

anomalous muscles reported are extensor indicis proprius (EIP), the extensor digitorum brevis manus (EDBM), the extensor medii proprius (EMP), the extensor indicis et medii communis, and the extensor indicis brevis manus (EIBM) [1-5]. Also, the dorsum of the hand may show variations in attachments of tendons of the muscles as well as supernumerary muscles in the hand [1,6].

The presence of additional muscle bellies could show variations with respect to shape and also may appear to be a ganglion, soft tissue tumour, or mass in the hand, which could be quite misleading to the surgeons [7]. In extensors of hand, the Extensor digitorum (ED) divides distally into four tendons to medial four fingers in the dorsum of hand. These tendons pass in a common synovial sheath along with the tendon of extensor indicis (EI), in a fascial tunnel deep to extensor retinaculum. The variations in the arrangements of tendons of ED are often identified. There may be many tendons passing through one or more digits or it may be deficient. The prevalence of double and triple tendons is more frequently observed in index and middle finger [8]. Also, a double tendon of extensor digiti minimi (EDM) and absence of ED tendon for the little finger that is 5th digit has been reported in previous literature [9-10].

Embryology and Evolutionary Significance: The extensor muscles of the forearm develop from mesoderm of the upper limb bud. On the extensor aspect of the radial side the mesoderm divides into an outer superficial and inner deep. The deep part of the mesoderm supplied by posterior interosseus nerve develops into abductor pollicis longus and the extensor pollicis brevis on radial side and extensor pollicis longus and EI on the ulnar side [11]. Compared to the superficial the deep portion has gone through evolutionary changes in different primate species as seen in comparative anatomy studies. This evolutionary process may be the reason that we encounter anatomical variations in deep extensors of hand [12].

Reporting of the type of variations and arrangements of muscles bellies and tendons may contribute to the literature, will be useful guide for study relating to human and comparative anatomy. In surgeries, the presence of additional tendinous slips may help in tendon replacement procedures of ruptured tendons.

Thus, in this work we are reporting the incidence of variations encountered after dissecting 54 upper limb specimens that will be useful to correlate if such variations are encountered during surgeries related to tendon repair, transfer, or reconstruction and also, while teaching anatomy during dissections.

MATERIALS AND METHODS

The present study was conducted in the Anatomy Department of an undergraduate & postgraduate teaching Medical College in India. A total of 54 formalin fixed upper limbs were used for the current study. The skin, superficial fascia, and deep fascia of the extensor compartment of the forearm were dissected and the extensor retinaculum covering the extensor compartment was split vertically to expose underlying tendons. The individual extensors muscles and the tendons were traced from their origin to insertion to identify for the presence of any additional muscles and tendons. The findings were noted and photographed.

RESULTS

Out of the 54 upper limbs studied, the variant muscles and tendons were observed in 10 limbs (18.5%). In 5 limbs specimens (9.3%) EMP muscles were identified of which 3 were in left limb (5.6%) and 2 on the right (3.7%). This muscle was located in a deeper plane to the tendons of ED. Further, the proximal muscle attachment was noted immediately distal to the attachment of EI muscle on the ulna. It had only one long tendon passing through the 4th compartment of the extensor retinaculum along with EI and ED. Distally, the muscle inserted into the middle finger on the base of proximal phalanx in the dorsum (**Fig.1A&B**). There were no tendinous inter-connections between any portion of EMP muscle and any extensor tendon. The nerve supply of EMP was from the posterior interosseous nerve.

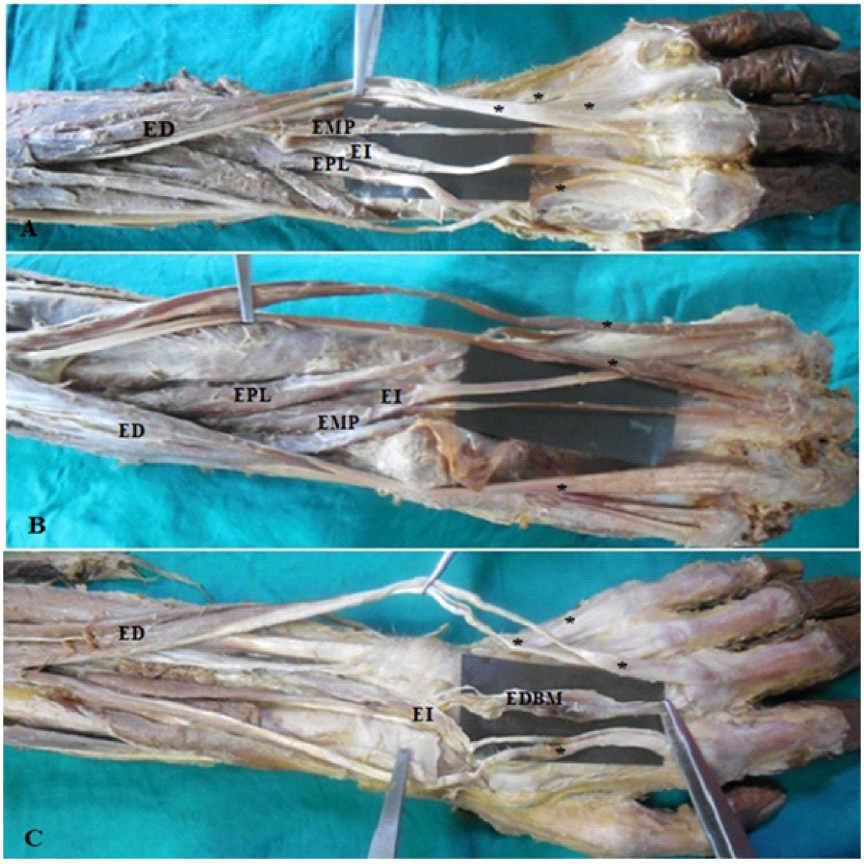

Fig. 1: Dissections of Dorsum of hand.

(A) Left dorsum of hand with extensor medii proprius (EMP) muscle.
(B) Right dorsum of hand with EMP.
(C) Left dorsum of hand, the extensor digitorum brevis manus muscle (EDBM) is seen.
ED – Extensor digitorum, EMP - Extensor mediiproprius, EI – Extensor indicis, EPL – Extensor pollicis Longus, EDBM - Extensor digitorum brevis manus, * - Tendons of extensor digitorum.

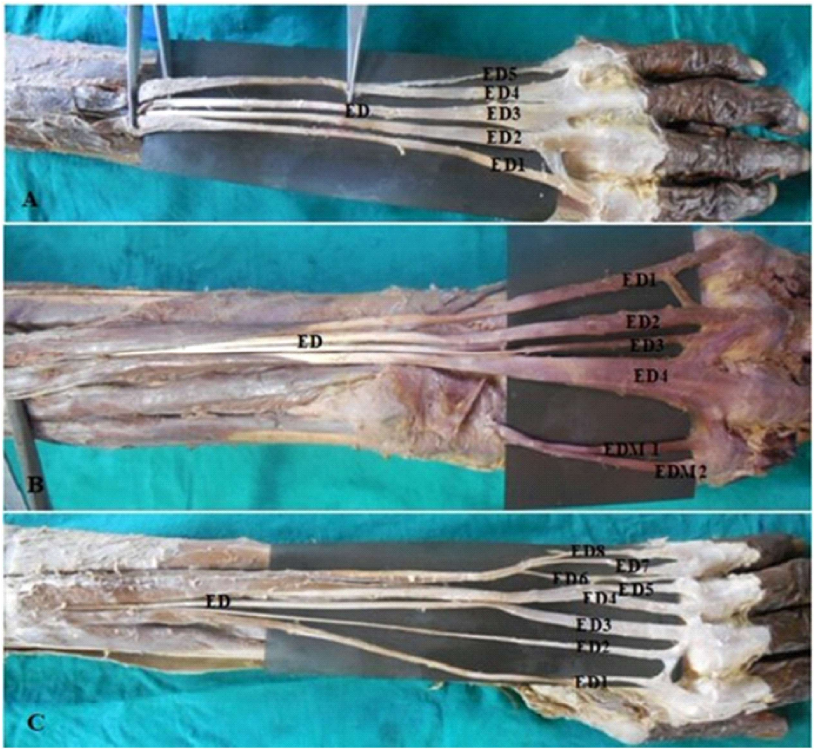

Fig. 2: Dissection of Dorsum of Hand to showing variations of Extensor Digitorum.

(A) Dorsum of the left hand showing the additional tendons in 4th digit of extensor digitorum (ED). Tendons of extensor digitorum (ED1, ED2, ED3, ED4, ED5)
(B) Dorsum of the right hand showing the additional tendons of ED with absence of ED to 5th digit and the double tendon of extensor digiti minimi (EDM 1and EDM 2)
(C) Dorsum of the left hand showing 8 tendons of ED (ED1, ED2, ED3, ED4, ED5, ED6, ED7, ED8)

The presence of EDBM was found in 2 limbs on the left (3.7%). This muscle was seen to originate from dorsal wrist capsule in the fourth compartment of extensor retinaculum and its insertion was into the extensor hood of middle finger (**Fig.1C**). The muscle was medial to the tendon of EI and lateral to the tendon of ED of the middle finger. The nerve supply of the muscle identified was posterior interosseous nerve.

With respect to ED there were variations in 3 limbs (5.6%). In one specimen five tendons were identified on the left upper limb (1.9%), where in tendon to the 5th digit was double and was seen distal to the extensor retinaculum and it was attached to the extensor hood of little finger (**Fig.2A**). In another right upper limb specimen presence of 4 tendons were identified in ED, one each to indicis and ring fingers and 2 tendons to the middle finger were seen proximal to ER and the tendon to little finger was absent, but the EDM had two tendons to the little finger (**Fig.2B**). Third variation of ED was the presence of eight tendons in left upper limb (1.9%). The tendon of ED to the middle finger proximal to extensor retinaculum was two and it was connected to the tendon of index finger as well. The tendon to the ring finger was seen as two distal to extensor retinaculum and it was connected to the tendon of middle finger. The tendon of the little finger distal to the extensor retinaculum had split into three, one to the ring finger and two to the little finger (**Fig.2C**).

DISCUSSION

Morphology of extensors of the hand and their tendons on the dorsum are significant while treating musculoskeletal conditions for appropriate assessment and management of the hand injuries, by clinicians, surgeons, and allied health practitioners particularly while considering for tendons transfers or reconstruction surgeries [13].

Extensor medii proprius: In the current study EMP was identified in 5 upper limb (9.3%) specimens. These muscles took origin from the ulna immediately distal to the EI and were inserted into the dorsal aspect of base of proximal phalanx of the middle finger [14], these muscles were located in the deep layer, covered by the ED of the extensor compartment of forearm. No tendinous connections were observed between EMP and other tendons in the dorsum of hand. According to standard anatomical reference books, the tendon of EMP appears as double, which may send a tendinous slip to ED tendon of the ring finger [8]. The passive traction on the tendon of the EMP muscle results in the extension of the proximal phalanx of the middle finger and it may act as an extensor of the wrist and metacarpophalangeal joint [13].

The incidence of EMP has been reported to be 1% to 12% in cadaver studies, in the current study it is 9.3%. **Table1** reports the incidence of EMP in literature [13, 15-18]. EMP is observed more frequently in males than females, but it is not frequently described in anatomical dissections since it is a small muscle in width and is covered by the tendons of ED [19].

Extensor digitorum brevis manus:

On the dorsum of the hand EDBM was first reported as a supernumerary muscle in the 18th century by the anatomist Albinus [20].

Further extensive studies on this muscle have been done and reported. In a meta analysis study true cadaveric prevalence rate of EDBM was reported as 2.5% in dissected hands and 4% in dissected cadavers [21]. In the present study, the incidence of EDBM was 3.7 %. Many variations regarding the attachments of EDBM have been reported. The most common origin of EDBM is the dorsal radiocarpal ligament and the capsule of wrist joint, insertion is frequently into the index and middle fingers [4,7]. Ogura et al had proposed 3 types of EDBM classification depending on its insertions and its relation to EI [7].

In this study the muscle belonged to type III where in the tendon of EDBM was inserted into the middle and EI into the Index finger. According to insertion, the EDBM can be named as extensor brevis digiti indicis vel medii, extensor digiti III brevis, extensor medii brevis, and extensor medii annularis brevis [20,22,23].

Table.1: Incidence of EMP.

Authors & Year of study	Country	Number. of specimens	Incidence %
Von Schroeder and Botte (1995)[13]	California	43	12
Jonathan S. Carlos (2011)[15]	Southern California	94	7.4
Dass et al(2011)[16]	Indian	100	9
Suwannakhan A et al (2016)[17]	Thailand	100	8
K. Ozturk et al (2020)[18]	Turkey	86	1.2
Present study	Indian	54	9.3

Table 2: Incidence of tendons of the extensor digitorum reported.

Authors & Year of study	No.of specimens (country of study)	Percentage Incidence of Number of tendons					
		Finger	Absent %	Single %	Double %	Triple %	Multiple %
Palatty BU et al (2015)[9]	50 (India)	Index finger	2	90	8		-
		Middle finger	-	72	26		2
		Ring finger	-	44	44		12
		Little finger	58	22	20	-	
Dass P et al (2011)[16]	100 (India)	Index finger	-	100	-	-	-
		Middle finger	-	931	7	-	-
		Ring finger	-	69	27	4	-
		Little finger	66	34		-	-
Celik S et al (2008)[26]	54 (Turkey)	Index finger	-	100	-	-	-
		Middle finger	-	92.6	7.4		-
		Ring finger	-	75.9	24.1		
		Little finger	68.5	24.1	-	-	-
Esther Yamun/a N et al (2017)[28]	70 (India)	Index finger	-	94.3	5.7	-	-
		Middle finger	-	58.6	25.7	15.7	-
		Ring finger	-	40	20	34.3	5.7
		Little finger	57.1	25.7	17.14	-	-
Present study	54 (India)	Index finger	-	100	-	-	-
		Middle finger	-	96.2	3.8	-	
		Ring finger	-	96.2	3.8	-	-
		Little finger	1.9	94.4	1.9	1.9	-

The EDBM can be a good source for tendon transfer for restoration of malfunctioning muscles like in case of damaged extensor pollicis longus [24]. A close physical examination of hand for differential diagnosis of tenosynovitis or a ganglion cyst becomes imperative where in the ganglion becomes prominent with wrist flexion and in active extension EDBM becomes prominent [23]. In the present study, the EDBM muscle was seen to extend into the fourth compartment of extensor retinaculum and this can lead to symptoms of chronic pain on the dorsal aspect of the hand and wrist. Hayashi, et al had coined the term “fourth compartment syndrome” for signs and symptoms of dorsal chronic pain within extensor retinaculum, this is caused due to compression of the posterior interosseous nerve and anterior interosseous artery because of increased pressure within the extensor retinaculum [25].

Extensor digitorum tendon: The tendons of ED that enter the digits show multiple variations in the number, they may be absent, double or triple and the variation is more frequently observed in the index or middle finger [12]. The present study had variations of ED in 3 limbs In the current study, the tendon of ED to index finger was single in all 54 specimens (100%), which was similar to the study of Dass P et al and Celik S et al [16,26]. Esther Yamuna N et al reported in 94.3% single and 5.7% of cases double tendon to the index finger. The absence of the tendon of the ED to the index finger was noticed in one specimen out of 120 upper limbs studied by Agarwal and Tirthani [27]. In 2%, of a specimen, the tendon of ED to the index finger was absent single in 90%, double and triple together in 8% observed by Palatty et al study [9].

There was an absence, double, and triple tendon of ED to the index finger not seen in the present study. Similarly, the number tendons of ED to other digits were varied while comparing the our studies with that of Palatty et al, Dass P et al ,Esther Yamuna N et al, ,and Celik S et al which is enumerated in **Table 2** [9, 16,26,28].

Duplication of tendon of EDM was observed in studies, with prevalence 62% in Hirai et al and 87% in El-Badawi et al study [30,31]. The tendon of the EDM is often split into two or more slips with occasionally a tendon to the ring finger [6]. Palatty et al has documented the absence of EDM in 2%, single in 18%, double in 70%, and triple in 10% of specimens [9]. Celik S et al had reported 88.9% of double EDM tendon which was the highest incidence as compared to previous studies [26]. In our study duplication of EDM was noticed with the absence of tendon to ED to the little finger.

CONCLUSION

Understanding these anatomical variations of hand and forearm becomes essential for clinicians to appreciate varying clinical manifestations affecting the hand and forearm [19]. The anatomical data of the present study would be helpful to modify the surgical procedures of the extensor tendons of the hand to attain adequate recovery of patients.

ABBREVIATIONS

EMP - Extensor medii proprius
EDBM - Extensor digitorum brevis manus
ED - Extensor digitorum
EIP - Extensor indicis proprius
EIBM - Extensor indicis brevis manus
EI - Extensor indicis
EDM - Extensor digiti minimi

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Conflicts of Interests: None

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