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Original Article

Anatomy Section

Morphology of Extensor Indicis Proprius Muscle in the North Indian Region: An Anatomic Study with Ontogenic and Phylogenetic Perspective

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ABSTRACT

Introduction: Variants on muscles and tendons of the forearm or hand occur frequently in human beings. They are often discovered during routine educational cadaveric dissections and surgical procedures.

Aim: To observe any variation of Extensor Indicis Proprius (EIP) muscle and to document any accessory muscles or tendons related to the index finger.

Materials and Methods: The EIP muscle was dissected in 60 upper limb specimens. After reflection of the skin and superficial fascia from the back of the forearm and hand, the extensor retinaculum was divided longitudinally and the dorsum of the hand was diligently dissected. The extensor tendons were delineated and followed to their insertions. Variations in the tendons of EIP and accessory muscles or tendons with respect to the index finger were noted and appropriate photographs were taken.

Results: In two limbs, the EIP muscle was altogether absent. In all the remaining 58 limbs, the origin of EIP was from the posterior surface of the distal third of the ulnar shaft. Out of these 58 limbs, this muscle had a single tendon of insertion in 52 limbs, whereas in the remaining six limbs it had two tendinous slips with different insertions.

Conclusion: Knowledge of the various normal as well as anomalous tendons on the dorsal aspect of the hand is necessary for evaluating an injured or diseased hand and also at the time of tendon repair or transfer. Awareness of such variants becomes significant in surgeries in order to avoid damage to the adjacent neurovascular structures.

Keywords: Anomalous, Extensor retinaculum, Variants

INTRODUCTION

The Extensor Indicis Proprius (EIP) muscle is one of the deep muscles of the extensor compartment of the forearm. It usually originates from the distal one third of the posterior surface of the shaft of ulna below the origin of the extensor pollicis longus and the adjoining interosseous membrane. It runs through the fourth extensor compartment along with the tendons of Extensor Digitorum Communis (EDC) under the extensor retinaculum. Opposite the head of the second metacarpal bone it joins the ulnar aspect of the extensor expansion of the index finger. This muscle allows independent extension of the index finger and by its continued action assists in extending the wrist and the midcarpal joints [1].

As per the available literature [2-5] no study has been conducted so far on the variations of the EIP muscle in the North Indian population. So we carried out a study on 60 cadaveric upper limbs of the North Indian origin and studied this muscle on the dorsal aspect of the forearm and wrist in detail, to observe any variation (in its origin or insertion) or multiplicity of its tendons and to document any accessory muscles or tendons related to the index finger. The morphological and clinical significance of the observed anomalous extensor indicis muscle along with the relevant ontogenic and phylogenetic background has also been discussed.

MATERIALS AND METHODS

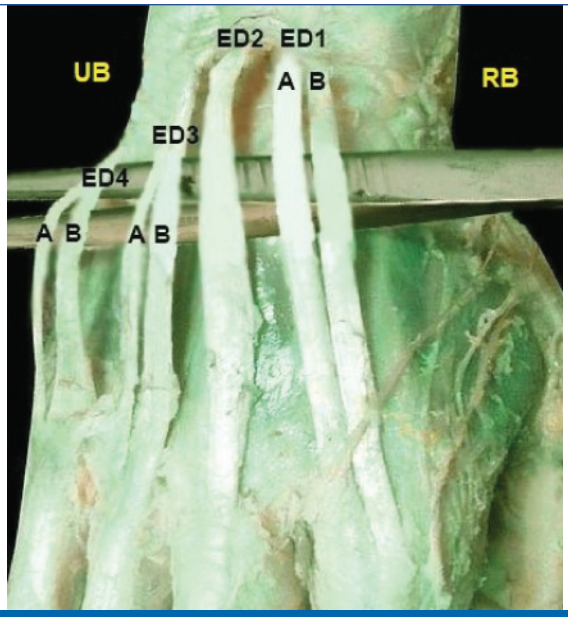
A routine cadaveric dissection study for the purpose of undergraduate teaching was done extending over a period of three consecutive years i.e., 2015-2017, in the Department of Anatomy, GGSMC, Faridkot. The study included 60 (30 right and 30 left) disarticulated upper limbs of adult North Indian cadavers of known sex (i.e., 58 male and 2 female limbs).

After the removal of skin and careful dissection of the superficial fascia on the dorsal aspect of each forearm and hand, the muscles of the extensor compartment were dissected. The extensor retinaculum was defined and was split vertically to expose the underlying tendons. The EIP muscle was identified and when present, the number of its tendons, proximal and distal to the retinaculum was investigated. The tendons were traced to their insertions in the fingers. The incidence of variations in their numbers and sites of attachment were observed. Then they were photographed using a digital camera. The obtained data was then tabulated and the percentages were calculated.

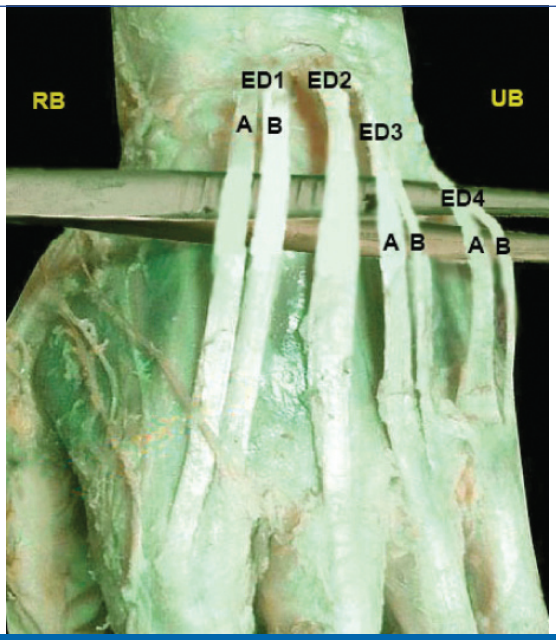
RESULTS

The EIP muscle was absent in two limbs. In these limbs, the index finger was receiving two tendons from EDC in place of one of EIP and one of EDC [Table/Fig-1,2]. In the remaining 58 limbs, the narrow, elongated muscle belly of EIP muscle originated as usual from the distal third of the posterior surface of the ulnar shaft and the adjacent interosseous membrane. As far as the insertion is concerned, in 52 limbs, EIP had a single tendon which inserted on the ulnar aspect of the dorsal digital expansion of the index finger [Table/Fig-3]. In the remaining six limbs (3 right and 3 left), the EIP muscle was replaced by Extensor Indicis Et Medii Communis (EletMC) muscle i.e., an extensor indicis muscle sending tendinous slips to both the index and middle fingers.

In these six limbs, the lateral part of the EletMC muscle belly became tendinous at the junction of the middle and distal thirds of the forearm while its medial part became tendinous opposite the proximal border of the extensor retinaculum. Subsequently, the tendon of extensor indicis et medii communis (T) split into two slips;



[Table/Fig-1]: Showing absence of extensor indicis proprius (Right hand).
(ED1, 2, 3, 4: Tendons of extensor digitorum communis (EDC) to the index, middle, ring and little fingers respectively, A, B: 2 tendinous slips of EDC to index, ring and little finger each, RB: Radial border, UB: Ulnar border)



[Table/Fig-2]: Showing absence of extensor indicis proprius (Left hand).
(ED1, 2, 3, 4: Tendons of extensor digitorum communis (EDC) to the index, middle, ring and little fingers respectively, A, B: 2 tendinous slips of EDC to index, ring and little finger each, RB: Radial border, UB: Ulnar border)

[Table/Fig-3]: Showing insertion of extensor indicis proprius into the ulnar aspect of the tendon of extensor digitorum to the index finger.
(ED1, 2, 3: Tendons of extensor digitorum to index, middle and little finger, EI: Extensor Indicis Proprius Muscle, EDM: Extensor Digiti Minimi, RB: Radial Border, UB: ulnar border).

Smaller Medial (TM) and Larger Lateral (TL), which travelled distally deep to the extensor retinaculum through the fourth extensor compartment along with the tendons of EDC. TL joined the ulnar aspect of the tendon of the EDC forming the Extensor Expansion for the Index Finger (EDCI). TM got inserted onto the distal half of the dorsal aspect of the shaft of third metacarpal [Table/Fig-4]. It was also observed that the bellies of these anomalous muscles were innervated by branches of the posterior interosseous nerve in the distal third of the forearm.

[Table/Fig-4]: Showing extensor indicis et medii communis muscle (EletMC).
(EDC: Extensor Digitorum Communis, T: Tendon of Eietmc, TL: Larger Lateral tendinous slip of EletMC, TM: Smaller medial tendinous slip of EletMC, EDCI: Tendon of EDC forming the extensor expansion of the index finger, Arrow: Indicates the insertion of TM on the distal half of the dorsal surface of the third metacarpal bone, RB: Radial border, UB: Ulnar border)

No accessory muscle was seen in relation to the index finger in all the 60 limbs studied.

DISCUSSION

The extensors of the forearm are known to exhibit wide range of variations, often asymptomatic and an incidental finding [2,6-11]. Among the extensors, EIP muscle is well known to associate with the variations in its origin, insertion and existence of accessory muscles of the index finger [3,11,12].

Review of literature shows that the extensor tendons to the index finger mostly include a tendon from EDC and another from EIP [13]. Studies have also shown that a great variability exists in the number of tendons of EIP muscle [3,7-9,11]. [Table/Fig-5] depicts the frequency of these variants according to different authors [3-11,13-24].

Yammine K reviewed studies on 3858 limbs and found on meta-analysis that the EIP tendon was single in 92.6%, double in 7.2% and triple in 0.2% limbs [25]. On comparison with other populations (i.e., Japanese, Europeans and North Americans) it was observed that the percentage incidence of EIP with a single tendon was the highest while that of EIP with a double tendon was the lowest in the Indian populations.

Though the most common pattern of insertion of EIP reported in the various anatomical studies is a single tendon lying mostly ulnar [7,13] and occasionally radial [9,26] to the EDC–index finger, several variations have been described related to its tendon of insertion (i.e. its number and site of attachment). These variations include: supernumerary EI tendon slips to the index finger; all either ulnar [2,3] or radial [24] to the EDC-index or some ulnar and other radial to EDC-index [3,24], extensor pollicis et indicis i.e., EIP tendon sending slips for insertion onto both the thumb and index finger [6], extensor medii proprius i.e., EIP tendon sending slips to both the middle and ring fingers [27], extensor indicis et medii communis i.e. EIP giving tendinous slips to both index and middle fingers [2,3], EIP with tendons to the second, third and fourth fingers [2].

Comparison between the numbers of cases showing extensor indicis et medii communis in the present study with the other studies available in literature is shown in [Table/Fig-6] [2,3,9,11,15,18,22,24,28-31]. Yammine K reviewed studies on 3858 limbs and found on meta-analysis that the EletMC was present in average of 1.6% of the hands, and was more prevalent in North American populations

Author/s	Place	Year	No. of limbs studied	No. of limbs with a single slip of EIP	No. of limbs with 2 slips of EIP	No. of limbs with 3 slips of EIP	No. of limbs with EIP absent
Mori M [14]	Japan	1964	200	176 (88%)	24 (12%)	0 (0%)	0 (0%)
Schenck R [15]	USA	1964	57	57 (100%)	0 (0%)	0 (0%)	0 (0%)
Mestdagh H et al., [16]	France	1985	150	140 (93%)	9 (6%)	0 (0%)	1 (1%)
Godwin Y et al., [6]	Cambridge, England	1992	50	46 (92%)	4 (8%)	0 (0%)	0 (0%)
Perkin RE et al., [17]	Chicago, Illinois, USA	1993	80	50 (62.5%)	30 (37.5%)	0 (0%)	0 (0%)
El-Badawi MG et al., [11]	Riyadh, Saudi Arabia	1995	181	164 (90.61%)	9 (4.97%)	7 (3.87%)	1 (0.55%)
Von Schroeder HP et al., [9]	California, USA	1995	43	33 (77%)	7 (16%)	3 (7%)	0 (0%)
Gonzalez MH et al., [3]	Chicago, USA	1996	72	60 (83.3%)	10 (13.89%)	0 (0%)	2 (2.78%)
Hirai Y et al., [7]	Japan	2001	548	471 (86%)	77 (14%)	0 (0%)	0 (0%)
Zilber S et al., [8]	France	2004	50	39 (78%)	9 (18%)	0 (0%)	2 (4%)
Celik S et al., [13]	Turkey	2008	54	54 (100%)	0 (0%)	0 (0%)	0 (0%)
Ranade AV et al., [18]	Mangalore, Karnataka	2008	72	68 (94%)	1 (0.72%)	0 (0%)	3 (4.2%)
Aggarwal P et al., [19]	Jabalpur, India	2011	120	116 (96.66%)	1 (0.83%)	0 (0%)	3 (2.5%)
Dass P et al., [20]	Mangalore, Karnataka	2011	100	98 (98%)	2 (2%)	0 (0%)	0 (0%)
Abdel-Hamid GA et al., [10]	Egypt	2013	95	95 (100%)	0 (0%)	0 (0%)	0 (0%)
Ferreira AH [21]	Colombia, South America	2015	26	26 (100%)	0 (0%)	0 (0%)	0 (0%)
Kumka M [22]	Toronto, Canada	2015	32	30 (93.75%)	2 (6.25%)	0 (0%)	0 (0%)
Palatty BU et al., [23]	Tamilnadu, India	2015	50	39 (78%)	5 (10%)	4 (8%)	2 (4%)
Suwannakhan A et al., [24]	Bangkok, Thailand	2016	100	96 (96%)	4 (4%)	0 (0%)	0 (0%)
Esther Yamuna N et al., [4]	Tamilnadu, India	2017	70	(85.7%)	0 (0%)	0 (0%)	(14.2%)
Shivarama, Shishirkumar CH [5]	Mangalore, Karnataka	2018	80	69 (86.25%)	8 (10%)	2 (2.50%)	1 (1.25%)
Present study	Punjab, India	2018	60	52 (86.67%)	6 (10%)	0 (0%)	2 (3.33%)

[Table/Fig-5]: Comparison of the number of tendinous slips of the EIP muscle observed by different authors [3-11,13-24].

Author/s	Place	Year	Total no. of limbs studied [n]	No. of limbs showing extensor indicis et medii communis (EletMC) [n(%)]
Straus WL [28]	New York	1941	48	5 (10.42%)
Cauldwell EW et al., [2]	Chicago, Illinois	1943	263	17 (6.46%)
Schenck R [15]	USA	1964	57	2 (3.51%)
Yoshida Y [29]	Japan	1990	832	12 (1.44%)
Schroeder HP et al., [30]	California, USA	1991	58	2 (3.45%)
El-Badawi MG et al., [11]	Riyadh, Saudi Arabia	1995	181	8 (4.42%)
Von Schroeder HP et al., [9]	California, USA	1995	43	2 (4.65%)
Gonzalez MH et al., [3]	Chicago, USA	1996	72	1 (1.39%)
Yalcin K et al., [31]	Ankara, Turkey	2006	62	3 (4.84%)
Ranade AV et al., [18]	Mangalore, Karnataka	2008	72	1 (1.39%)
Kumka M [22]	Toronto, Canada	2015	32	2 (6.25%)
Suwannakhan A et al., [24]	Bangkok, Thailand	2016	100	4 (4%)
Present study	Punjab, India	2018	60	6 (10%)

[Table/Fig-6]: Incidence of extensor indicis et medii communis (EletMC) muscle in dissection studies by different authors [2,3,9,11,15,18,22,24,28-31]..

followed by Europeans [25]. Non-significance was found between Indians and Japanese (p = 0.3).

In majority of the studies mentioned in [Table/Fig-6], the accessory tendon of EletMC was inserted either ulnar, radial or volar to the extensor expansion of the middle finger [2,3,11,15,18,22,24,29]. On the contrary, in all the six cases in our study, this slip was inserted onto the distal half of the dorsal aspect of the shaft of third metacarpal bone in our study. The insertion of the additional tendon onto the dorsal aspect of the capsule of the metacarpophalangeal joint of the middle finger or into the deep fascia proximal to this joint is documented in literature [9,12,30,31] but the one seen in our cases is first of its kind to the best of our knowledge.

Developmental and Phylogenetic Basis

During the embryological development of the extensor muscles of the forearm, the primitive extensor mass of the forearm divides into two parts i.e., radial and ulnar. The radial part further differentiates to form three muscles which include brachioradialis, extensor carpi radialis longus and extensor carpi radialis brevis. The ulnar part then divides into a superficial portion that forms three muscles (i.e., extensor digitorum communis, extensor carpi ulnaris and extensor digiti minimi) and a deep portion that forms four muscles (i.e., abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus and extensor indicis). It has been observed that the superficial and radial portions are phylogenetically more stable than the deeper one. This observation supports the fact that majority of the variations recorded in the musculature of the posterior compartment of the forearm occur within the deeper portion [32].

During the development of the limb musculature in the fetal life, the skeletal muscles of limbs are composed of the myogenic cells derived from the somitic myotomes along with the epimysium and

tendinous component derived from the adjoining somatopleuric mesoderm. Variations including tendon duplications may occur due to the anomalies in the aggregation of the myogenic cell masses or in the formation of the tendinous components [33]. Anomalous extensor tendons to the fingers, as in the present case, could be the result of regression, retention or the reappearance of the changes that the musculature undergoes during its ontogenic development [13,14].

Phylogenetic comparisons between species show that the extensor medii proprius or EletMC are found in old world monkeys (the Cercopithecinae and the Colobinae subfamilies) such as baboons and macaques; in contrast, the great apes (including chimpanzees and gorillas) have an extensor indicis proprius, with the EIP or EletMC being variable with a prevalence similar to humans [28]. This suggests that the extensor medii proprius and EletMC are evolutionary remnants and not variations of a normal arrangement [30].

The EletMC is similar to the extensor indicis complex found in many primates including strepsirhines, tarsius and catarrhines where the muscle goes to both the index and the middle finger [34].

Clinical Implications

Hand being the most frequently used part of our body is very much prone to injury. So the knowledge of the various normal and anomalous extensors of the hand becomes important to avoid any complications whenever surgeries are carried out in this region [18].

Review of literature shows that the extensors of the human hand show considerable variations [6-11]. Variant muscles are often a matter of concern to clinicians as they mislead the diagnosis since such anomalous muscles may be confused with synovial cyst, ganglion, synovitis, exostosis and soft tissue tumor. Adequate knowledge of these variant muscles assists accurate interpretation of MRI scans of this region and also the proper diagnosis and management of certain rare clinical conditions [35].

According to McMinn, in the fourth compartment of extensor tunnel all the four tendons of EDC lie crowded together over the tendon of extensor indicis along with the posterior interosseous nerve and artery. So presence of one additional tendon in this rigid fibro-osseous compartment can increase the possibilities of muscle compression and subsequent pain in the various members of this compartment. This is called the “fourth compartment syndrome” wherein the pain in the dorsal wrist is produced by the increase of pressure in the fourth compartment, which leads to a direct or indirect compression of the posterior interosseous nerve [36]. Hence, an awareness of existence of such an anomalous muscle is the basis for recognition and proper treatment of this condition.

The supernumerary tendons of the EIP as found in the current study could be safely and effectively utilized for reconstructions or tendon transfer operations in case of traumatic injuries or to treat nerve lesions and degenerative disorders. Also it is important to recognize these variations while harvesting the extensor indicis tendon so as not to damage the adjoining tendons of EDC [37].

LIMITATION

Since our study material included only a single female cadaver (i.e., 2 limbs out the total 60 limbs studied) the relationship between the sex and the incidence of the variations observed in the study could not be established.

CONCLUSION

The observations made in the present study will supplement our knowledge of variations in this region, which should be quite useful in forearm and hand surgery.

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