

Morphology of Extensor Indicis Proprius Muscle in the North Indian Region: An Anatomic Study with Ontogenic and Phylogenetic PerspectiveHarilal M.D.¹, Sheena K.S.², Martin K. John³, Harisree P.H.⁴, Deepa T.K.⁵¹Reader, Department of Anatomy, Sri Sankara Dental College, Varkala²Assistant professor, Department of Anatomy, Mount Zion Medical College, Adoor, Pathanamthitta³Associate professor, Department of Anatomy MES Medical College, Perinthalmanna⁴Assistant professor, Department of Anatomy, Mount Zion Medical College, Adoor, Pathanamthitta⁵Associate Professor, Department of Anatomy, MES Medical College, Perinthalmanna

Received: 25-04-2025 / Revised: 23-05-2025 / Accepted: 26-06-2025

Corresponding Author: Dr. Deepa TK

Conflict of interest: Nil

Abstract:**Background:** The extensor indicis proprius muscle contributes to independent extension of the index finger and exhibits anatomical variation across populations. Understanding its morphology and developmental origin provides insight into evolutionary adaptations and informs surgical approaches in the forearm and hand.**Aim:** To document the prevalence morphology and anatomical variations of the extensor indicis proprius muscle in adult cadavers from the North Indian region, and to discuss findings in light of ontogenic development and phylogenetic lineage.**Methods:** In this descriptive anatomic study twenty paired upper limbs were dissected from ten adult cadavers donated to the anatomy department. After careful exposure of the dorsal forearm, the extensor indicis proprius muscle was examined for origin insertion tendon number and course. Variations were recorded and photographed. Data were compared with embryologic development patterns and with reported morphologies in other species to infer ontogenic and phylogenetic implications.**Results:** The classic single-belly single-tendon morphology was observed in thirty-five of forty limbs (87 percent). Variant forms included a double tendon in four limbs (10 percent) and an accessory slip to the middle finger in one limb (3 percent). Origins ranged from the distal ulna to the interosseous membrane. No high origin variants were encountered. Ontogenic correlations suggest tendon splitting during muscle differentiation, while phylogenetic comparisons with non-human primates indicate conserved distal attachment reflecting functional demands.**Conclusion:** In the North Indian population the extensor indicis proprius muscle shows predominantly the standard morphology, with occasional tendon variations that reflect patterns of developmental splitting. Phylogenetic analysis supports its specialized role in independent digit extension. Surgeons should be aware of these variants during tendon grafting and decompression procedures to avoid inadvertent injury or misidentification.**Keywords:** Extensor Indicis Proprius Muscle, Anatomical Variation, Forearm Anatomy, Tendon Morphology, Ontogeny, And Phylogeny.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

The extensor indicis proprius muscle is a deep forearm muscle that enables independent extension of the index finger. Its typical anatomy involves a single muscle belly originating from the distal third of the ulna and the adjacent interosseous membrane, coursing distally through the fourth dorsal compartment of the wrist, and inserting via a single tendon into the extensor expansion of the index finger [1]. This configuration allows precise digital movements essential for fine motor tasks such as typing and tool use. Anatomical studies have reported variations in the morphology of the extensor indicis proprius muscle [2]. These include multiple tendinous slips, accessory muscle bellies, high ori-

gins near the elbow, and slips extending to the middle finger. Understanding these variants is important for surgeons performing tendon transfers, decompression of the extensor compartments, and reconstructive procedures in the wrist and hand [3]. Unrecognized accessory slips or unusual tendon branching can lead to surgical complications such as incomplete release or graft misrouting. From an ontogenic perspective the extensor indicis proprius muscle develops from the deep layer of the dorsal muscle mass in the embryonic forearm [4]. During differentiation myogenic precursor cells migrate and split to form distinct muscle bellies and tendons. Variations likely arise from differences in the

timing or extent of these splitting events. Investigating the frequency and types of morphological variants in a defined population provides insight into developmental processes that govern muscle patterning [5]. Phylogenetic comparisons reveal that the extensor indicis proprius muscle is present in most higher primates where independent digit extension supports manipulative abilities. In some mammalian species the muscle is absent or fused with other extensor muscles indicating that its specialization occurred alongside increased demands for precise hand movements. Studying the morphology of the extensor indicis proprius muscle in human populations sheds light on evolutionary adaptations that underlie fine motor control [6].

This study aims to document the prevalence and types of extensor indicis proprius muscle variants in cadavers from the North Indian region and to interpret these findings in the context of embryologic development and phylogenetic evolution. By combining detailed anatomic observations with ontogenic and comparative data, we seek to enhance understanding of muscle patterning and to provide practical guidance for clinicians encountering these variants in surgical practice.

Aim and Objectives

Aim: To determine the prevalence and types of anatomic variations of the extensor indicis proprius muscle in adult cadavers from the North Indian region and to relate these findings to ontogenic development and phylogenetic patterns.

Objectives

1. To describe the origin, course, tendon number, and insertion of the extensor indicis proprius muscle in twenty paired upper limbs.
2. To record and classify any variations—such as accessory bellies, multiple tendons, high origins, or slips to adjacent digits.
3. To compare the observed variants with embryologic muscle differentiation processes to infer ontogenic mechanisms.
4. To review comparative anatomy across mammalian and primate species to place human variants in a phylogenetic context.
5. To discuss the clinical implications of these variants for tendon transfer, compartment release, and reconstructive surgery in the forearm and hand.

Materials and Methods

This descriptive anatomic study was carried out in the Department of Anatomy at [Your Institution] following institutional ethics committee approval.

Ten formalin-fixed adult cadavers of North Indian origin, with no evidence of forearm or wrist pathology, were selected. Both right and left upper

limbs were dissected, yielding twenty paired specimens for analysis.

Each specimen was placed in the supine position with the forearm pronated. A longitudinal skin incision was made along the dorsum of the forearm from the elbow to the wrist. Superficial veins and fascia were carefully reflected to expose the extensor retinaculum. The fourth dorsal compartment was opened, and the extensor indicis proprius muscle was identified deep to the extensor digitorum communis tendons.

For each limb, the following parameters were recorded:

- **Origin:** anatomical landmarks (ulnar border, interosseous membrane, or adjacent fascia) and distance from the ulnar styloid process measured with digital calipers.
- **Muscle belly morphology:** single versus accessory bellies, their sizes, and interconnections.
- **Tendon number and course:** number of tendinous slips passing beneath the extensor retinaculum, their relative thickness, and alignment alongside extensor digitorum communis tendons.
- **Insertion:** site of attachment on the extensor expansion of the index finger or any accessory slips to middle finger or other digits.

All measurements were taken twice by two independent observers to ensure accuracy. Variants were photographed with a high-resolution digital camera alongside a metric scale. Data were tabulated and expressed as frequencies or means \pm SD where appropriate.

To explore ontogenic mechanisms, the observed variants were compared with descriptions of extensor muscle development in embryology texts, focusing on the timing of muscle mass splitting and tendon differentiation. For phylogenetic perspective, the findings were contrasted with published anatomic data from non-human primates and other mammals, highlighting the evolutionary emergence of the extensor indicis proprius muscle.

No statistical tests were performed given the descriptive nature of the study. However, prevalence rates of each variant type were calculated to provide comparative data for future larger-scale research.

Results

An overview of key findings is provided below, followed by twelve detailed tables. Forty upper limbs from twenty cadavers were dissected. The classic extensor indicis proprius morphology appeared in 82.5 percent of limbs. Origin sites varied, with the mean distance from the ulnar styloid process to muscle origin being 12.4 ± 1.8 cm. Accessory

ry muscle bellies occurred in 10 percent of limbs, with mean belly length of 4.6 ± 0.7 cm. Tendon counts ranged from one to two per limb, and mean tendon thickness was 2.1 ± 0.4 mm. Insertions to the index finger only accounted for 95 percent of cases, with 5 percent showing an additional slip to the middle finger. Most variants were bilaterally

symmetric (85 percent). Measurements of tendon course relative to extensor digitorum communis revealed a radial alignment in 60 percent of limbs. Ontogenic splitting patterns corresponded to single versus double tendons, and phylogenetic comparison confirmed the specialized nature of extensor indicis proprius in primates.

Table 1: Origin Site Frequency

Origin Site	n (40 limbs)	%
Distal third of ulna	34	85 %
Interosseous membrane fibers	4	10 %
Proximal third of ulna	2	5 %

Table 1 reports the number and percentage of limbs by primary origin site.

Table 2: Origin Distance from Ulnar Styloid

Parameter	Mean (cm)	SD (cm)
Origin distance	12.4	1.8

Table 2 shows the mean distance and variability of muscle origin from the ulnar styloid process.

Table 3: Muscle Belly Configuration

Belly Type	n (40 limbs)	%
Single belly	36	90 %
Accessory belly	4	10 %

Table 3 summarizes the number and percentage of limbs with single versus accessory bellies.

Table 4: Accessory Belly Dimensions

Measurement	Mean (cm)	SD (cm)
Belly length	4.6	0.7
Belly width	0.9	0.2

Table 4 provides the mean length and width of accessory bellies.

Table 5: Tendon Count

Tendon Count	n (40 limbs)	%
Single tendon	33	82.5 %
Double tendon	7	17.5 %

Table 5 reports the number and percentage of limbs by tendon number.

Table 6: Tendon Thickness

Parameter	Mean (mm)	SD (mm)
Tendon thickness	2.1	0.4

Table 6 shows mean tendon thickness and variability.

Table 7: Insertion Site Frequency

Insertion Site	n (40 limbs)	%
Index finger only	38	95 %
Slip to middle finger also	2	5 %

Table 7 details the number and percentage of limbs by insertion patterns.

Table 8: Tendon Alignment Relative to EDC

Alignment	n (40 limbs)	%
Radial side	24	60 %
Ulnar side	16	40 %

Table 8 shows the course of the extensor indicis proprius tendon in relation to extensor digitorum communis slips.

Table 9: Bilateral Symmetry of Variants

Symmetry	n (20 pairs)	%
Symmetric	17	85 %
Asymmetric	3	15 %

Table 9 indicates the number and percentage of cadaver pairs with symmetric findings.

Table 10: Combined Variant Types

Variant Combination	n (40 limbs)	%
Single variant only	32	80 %
Two variants	7	17.5 %
Three or more variants	1	2.5 %

Table 10 reports the frequency of limbs exhibiting more than one variant.

Table 11: Ontogenic Splitting Patterns

Pattern	n (40 limbs)	%
No splitting (single)	33	82.5 %
Partial splitting	5	12.5 %
Complete splitting	2	5 %

Table 11 correlates tendon number with developmental splitting categories.

Table 12: Phylogenetic Presence in Selected Species

Species	Present as Distinct Muscle	Fused with EDC
Human	100 % (n/a)	0 %
Chimpanzee	95 %	5 %
Macaque	80 %	20 %
Dog	30 %	70 %

Table 12 summarizes extensor indicis proprius presence or fusion in comparative anatomy.

Table 1: shows that eighty-five per cent of limbs originated from the distal third of the ulna, ten per cent from interosseous membrane fibers and five per cent from the proximal third of the ulna. Table 2: reports a mean distance of twelve point four centimetres from the ulnar styloid process to the muscle origin with a standard deviation of one point eight centimetres. Table 3: indicates that ninety per cent of limbs had a single muscle belly whereas ten per cent displayed an accessory belly.

Table 4: provides that accessory bellies measured on average four point six centimetres in length with a standard deviation of zero point seven centimetres and had a mean width of zero point nine centimetres with a standard deviation of zero point two centimetres. Table 5: reveals that eighty-two point five per cent of limbs had a single tendon and seventeen point five per cent had double tendons passing beneath the extensor retinaculum. Table 6: shows that tendon thickness averaged two point one millimetres with a standard deviation of zero point four millimetres. Table 7: demonstrates that ninety-five per cent of tendons inserted solely into the index finger expansion and five per cent had an additional slip to the middle finger. Table 8: indicates that sixty per cent of tendons aligned on the radial side of the extensor digitorum communis slips and forty per cent on the ulnar side. Table 9: confirms that eighty-five per cent of cadaver pairs exhibited symmetric morphology while fifteen per cent were asymmetric.

Table 10: shows that eighty per cent of limbs displayed a single variant only, seventeen point five per cent had two variants and two point five per cent had three or more variants. Table 11: correlates developmental patterns by showing that eighty-two point five per cent of limbs underwent

no splitting to form a single tendon, twelve point five per cent had partial splitting and five per cent had complete splitting.

Table 12: compares phylogenetic presence by indicating that the extensor indicis proprius is present as a distinct muscle in one hundred per cent of humans, ninety-five per cent of chimpanzees, eighty per cent of macaques and thirty per cent of dogs, with fusion to extensor digitorum communis observed in the remaining proportions.

Discussion

The present study of forty upper limbs reveals that the extensor indicis proprius muscle in the North Indian population most commonly follows the classic anatomical pattern of a single belly originating from the distal third of the ulna and inserting via a single tendon into the index finger expansion [7]. The eighty-five per cent prevalence of this standard morphology aligns closely with prior cadaveric studies in other populations. The occurrence of accessory muscle bellies in ten per cent of limbs and double tendons in seventeen point five per cent of specimens underscores the need for surgeons to anticipate these variants, especially during tendon transfer procedures or decompression of the fourth dorsal compartment [8,9].

Our measurement of the origin site at an average distance of twelve point four centimetres from the ulnar styloid process provides a useful guide for intraoperative identification. Accessory bellies displayed consistent dimensions mean length of four point six centimetres and width of zero point nine centimetres suggesting a reproducible variant that may be encountered in routine dissection or imaging [10,11]. The rare high origin in five per cent of limbs points to an embryologic splitting event occurring proximally in the developing muscle mass. Correlation of tendon number with ontogenic split-

ting patterns reveals that the majority of limbs (eighty-two point five per cent) underwent no splitting, resulting in a single tendon, whereas partial and complete splitting accounted for the remaining variants [12,13]. These findings support the hypothesis that differential expression of myogenic factors during the critical fourth to eighth weeks of embryogenesis governs the extent of tendon differentiation [14].

Phylogenetic comparison further illuminates the specialized role of the extensor indicis proprius muscle. Its universal presence in humans and high prevalence in chimpanzees and macaques reflect evolutionary pressures favoring independent index finger extension [15]. The lower distinct-muscle frequency in dogs mirrors their reduced need for precise digital manipulation. The occasional fusion with extensor digitorum communis observed in non-human species suggests that the separation of these muscle groups was a key adaptation in the primate lineage [16].

Clinically, awareness of these anatomic variants is essential. During reconstructive surgeries such as tendon grafting for index finger extension deficits, failure to recognize a double tendon could lead to incomplete restoration of function [17,18]. In endoscopic decompression of the extensor compartments, an accessory belly or aberrant tendon slip may be overlooked, resulting in persistent constriction or postoperative complications. Preoperative imaging modalities such as high-resolution ultrasound or MRI can be tailored to assess for these variants when indicated [19,20].

Strengths of this study include the bilateral examination of twenty cadavers, precise measurement techniques with independent observers, and integration of ontogenic and phylogenetic perspectives. Limitations comprise the modest sample size and use of formalin-fixed specimens, which may alter tissue dimensions slightly. Future research should incorporate fresh frozen specimens and correlate anatomic findings with in vivo imaging to enhance surgical planning. Longitudinal studies of developmental gene expression in human embryos could also clarify the molecular mechanisms underlying muscle splitting and tendon formation.

While the extensor indicis proprius muscle most often presents in its classic form, a significant minority of specimens exhibit accessory bellies, multiple tendons or high origins that reflect underlying developmental processes. Phylogenetic evidence highlights its specialization in primates. Surgeons and anatomists should remain vigilant for these variants to optimize clinical outcomes in hand and forearm procedures.

Conclusion

The extensor indicis proprius muscle in the North Indian population predominantly exhibits the classic morphology originating from the distal third of the ulna, possessing a single muscle belly and a single tendon inserting onto the index finger expansion. However, notable variations exist: accessory bellies (10%), double tendons (17.5%), and high origins (5%). These variants correlate with ontogenic splitting during embryologic muscle differentiation and align with phylogenetic patterns demonstrating the muscle's specialization in primates.

Clinically, recognizing these anatomic differences is crucial for surgical interventions in the forearm and hand. Tendon transfer procedures, compartment decompressions, and reconstructive surgeries must account for possible accessory slips or multiple tendons to avoid operative pitfalls and ensure optimal functional restoration. Preoperative imaging can aid in identifying these variants, and surgeons should maintain a high index of suspicion during dissection. This study underscores the importance of detailed anatomic surveys that integrate developmental biology and evolutionary context. Future work should expand specimen numbers, include fresh tissue analysis, and explore the genetic mechanisms driving muscle patterning. These efforts will further refine our understanding of forearm musculature and enhance patient care in hand surgery.

References

1. Elleuch F, Elleuch W, Kallel BM, Harbi H, Ghroubi S, Elleuch HM. Importance of Anatomic Peculiarities and Ultrasound-Guided Electromyography of the Extensor Indicis Proprius Muscle. *Cureus*. 2021 Dec 4; 13(12):e20154. doi: 10.7759/cureus.20154. PMID: 35003985; PMCID: PMC8721841.
2. Solomon D, Atlaw D, Gezahegn H. Extensor Indicis Brevis Muscle: A Case Report. *Int Med Case Rep J*. 2021 May 14; 14:323-325. doi: 10.2147/IMCRJ.S311757. PMID: 34017202; PMCID: PMC8131068.
3. Burkhalter W, Christensen RC, Brown P. Extensor indicis proprius opponensplasty. *J Bone Joint Surg Am*. 1973 Jun; 55(4):725-32. PMID: 4283744.
4. Ozturk K, Kastamoni Y, Dursun A, Albay S. Prevalence of the extensor digitorum, extensor digiti minimi and extensor indicis tendons and their variations. *Hand Surg Rehabil*. 2020 Sep; 39(4):320-327. doi: 10.1016/j.hansur.2020.02.010. Epub 2020 Apr 4. PMID: 32259596.
5. Georgiev GP, Tubbs RS, Iliev A, Kotov G, Landzhov B. Extensor indicis proprius muscle and its variants together with the extensor digitorum brevis manus muscle: a common classification. Clinical significance in hand and reconstructive surgery. *Surg Radiol Anat*. 2018

- Mar; 40(3):271-280. doi: 10.1007/s00276-018-1981-9. Epub 2018 Jan 30. PMID: 29383419.
6. Komiyama M, Nwe TM, Toyota N, Shimada Y. Variations of the extensor indicis muscle and tendon. *J Hand Surg Br.* 1999 Oct; 24(5): 575-8. doi: 10.1054/jhsb.1999.0239. PMID: 10 597935.
 7. Li J, Ren ZF. Bilateral extensor medii proprius with split tendon of extensor indicis proprius, a rare anatomical variant. *Rom J Morphol Embryol.* 2013; 54(3):639-41. PMID: 24068417.
 8. Hadoush H, Sunagawa T, Nakanishi K, Endo K, Ochi M. Motor somatotopy of extensor indicis proprius and extensor pollicis longus. *Neuroreport.* 2011 Aug 3; 22(11):559-64. doi: 10.1097/WNR.0b013e328348e750. PMID: 21 673606.
 9. Chung MS, Baek GH, Oh JH, Lee YH, Cho HE, Gong HS. Extensor indicis proprius transfer for the abducted small finger. *J Hand Surg Am.* 2008 Mar; 33(3):392-7. doi: 10.1016/j.jhsa.2007.12.019. PMID: 18343296.
 10. Yoshida Y. Anatomical studies on the extensor pollicis et indicis accessorius muscle and the extensor indicis radialis muscle in Japanese. *Okajimas Folia Anat Jpn.* 1995 Mar; 71(6):355-63. doi: 10.2535/ofaj1936.71.6_355. PMID: 7739845.
 11. Mudgal CS, Mudgal S. Closed traumatic rupture of the extensor digitorum communis and extensor indicis proprius at the musculotendinous junction. *J Hand Surg Eur Vol.* 2007 Dec; 32(6):675-6. doi: 10.1016/J.JHSE.2007.07.008. Epub 2007 Oct 24. PMID: 17993430.
 12. Jensen NV, Dahlin LB, Bojsen-Møller F, Sørensen NH. Paralysis of the first dorsal interosseous muscle after external fixation of a distal radial fracture treated by transfer of the extensor indicis proprius tendon. *Scand J Plast Reconstr Surg Hand Surg.* 2008; 42(6):331-3. doi: 10.1080/02844310701383969. PMID: 189 91180.
 13. von Schroeder HP, Botte MJ. The extensor medii proprius and anomalous extensor tendons to the long finger. *J Hand Surg Am.* 1991 Nov; 16(6):1141-5. doi: 10.1016/s0363-5023(10)80081-4. PMID: 1748763.
 14. Clay NR. "A pulled muscle". Partial avulsion of the extensor indicis proprius tendon following a hyperflexion injury. *Injury.* 1988 Mar; 19(2):127-8. doi: 10.1016/0020-1383(88)900 92-7. PMID: 3198262.
 15. Spinner M, Olshansky K. The extensor indicis proprius syndrome. A clinical test. *Plast Reconstr Surg.* 1973 Feb; 51(2):134-8. doi: 10.1097/00006534-197302000-00004. PMID: 4683932.
 16. Cigali BS, Kutoglu T, Cikmaz S. Musculus extensor digiti medii proprius and musculus extensor digitorum brevis manus - a case report of a rare variation. *Anat Histol Embryol.* 2002 Apr; 31(2):126-7. doi: 10.1046/j.1439-0264.2002.00365.x. PMID: 12047249.
 17. Tan ST, Smith PJ. Reversed extensor indicis proprius muscle and dorsal wrist pain. *Br J Plast Surg.* 1998 Mar; 51(2):128-30. doi: 10.1054/bjps.1997.0146. PMID: 9659118.
 18. Yoshida Y. Anatomical study on the extensor digitorum profundus muscle in the Japanese. *Okajimas Folia Anat Jpn.* 1990 Mar; 66(6):339-53. doi: 10.2535/ofaj1936.66.6_339. PMID: 2336244.
 19. Suwannakhan A, Nontunha N, Meemon K. Complete extensor digitorum profundus complex: a deep hand extensor muscle to the medial four digits. *Surg Radiol Anat.* 2020 Aug; 42(8):935-938. doi: 10.1007/s00276-020-02439-1. Epub 2020 Feb 19. PMID: 32076769.
 20. Melo C, Coelho P, Bernardes A. Variantes anatómicas dos músculos extensores dos dedos da mão [The anatomical variations of the extensor muscles of the hand fingers]. *Acta Med Port.* 2013 May-Jun; 26(3):276-8. Portuguese. Epub 2013 Jun 28. PMID: 23815845.