Original Article

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Anatomy Section

Morphological Variations of the Lumbricals in Adult Cadaveric Hand: A Cross-sectional Study

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ABSTRACT

Introduction: The development of the human hand is unprecedented. Despite being tiny in size, the lumbricals play a far more significant role in the dynamic actions of the fingers. At the Metacarpophalangeal (MCP) and interphalangeal joints, they do flexion and extension. Lumbricals also exhibit some variations of developmental anomalies in attachments and morphology.

Aim: To classify morphological patterns of the lumbrical muscles and their anatomical variations in the hands and to discuss their clinical implications.

Materials and Methods: This cross-sectional study was conducted in the Department of Anatomy of Aarupadai Veedu Medical College and Hospital, Puducherry, India, from July 2020 to July 2021 on 50 disarticulated upper limbs during routine dissection of cadavers. In the present study, the limbs were labelled R or L for right or left, M or F for male or female. The variation in origin (including architecture), insertion (including split insertions, misplaced insertions, or absence of muscles, and the lengths of the muscle belly and tendon of all lumbricals were studied and noted. The dissection was carried out based on the steps as per Cunningham's manual. Analysis of the data was done using Microsoft excel software 2016.

Results: In this study, 86% of the lumbricals were found normal in origin, innervation and insertion. Split insertion in the 3rd lumbrical was seen in 6% of the lumbricals, and a unipennate in the fourth lumbrical was seen in 2% of the total specimens. In 2% of the specimens, the 4th lumbrical was absent, the 1st lumbrical was hypertrophied in 2%, and the accessory belly in the 2nd lumbrical was also observed in 2%.

Conclusion: The findings of this research may provide light on the role of the lumbrical muscles in diagnostic and surgical procedures involving the hands.

Keywords: Accessory belly, Hypertrophied, Misplaced insertion, Split insertion, Unipennate muscle

INTRODUCTION

The hand is a prehensile organ with grasping and precise motions for skilled work and is a major tactile apparatus. This is due to enhanced neuromuscular coordination and a more extensive cortical representation of the hand in the brain's sensory-motor cortex [1]. Ultimately, the human hand symbolises a change in evolution. Writing, sewing, and other delicate work rely on the lumbricals of the hand's ability to produce flexion at the Metacarpophalangeal (MCP) joints and extension at the interphalangeal joints [2]. From a philosophical point of view, it is possible to say that a race's level of civilisation can be seen in how its lumbar muscles work [3].

The four tendons of the Flexor Digitorum Profundus (FDP) give rise to the worm-like hand muscles known as lumbricals. Among the hand's intrinsic muscles, the lumbricals play a crucial role in the complex movements of the fingers [4]. They start in the palm at the FDP tendons and end in front of the deep, transverse metacarpal ligament. Each muscle develops a small tendon that connects the edge of the dorsal digital expansion as it reaches the dorsal surface of the proximal phalanx [5]. The lumbricals arise from the tendons of the FDP; the first and second lumbricals originate from the palmar surfaces of the tendons that attach to the index and middle fingers, respectively [6]. The third and fourth lumbricals emerge from the middle and ring fingers and the ring and little fingers. Even though lumbricals variations have been explained in standard anatomy textbooks and other surgical or anatomical literature, the basic anatomy of lumbricals of review will be helpful [7]. They go radially along the MCP joint, where they form a tendon at the level of the dorsal surface of the proximal phalanx and join the radial edge of the dorsal digitorum expansion to start a wing tendon [8]. The first and second lumbrical muscles are used as muscular flaps to cover the median nerve and its palmar branches [9]. Due to the importance of many hand injuries in road traffic accidents, the knowledge of such anatomical variations of lumbricals is essential for hand surgeons. A wide variety of consequences have been reported in the literature, ranging from complete loss of the lumbricals to a reduction in their volume or the presence of complementary slips [10]. Chronic subischaemia results from the lumbrical muscles' hypertrophy, compressing the radial and ulnar collateral arteries [11]. There is wide variation in the neurovascular structures of the hand between groups and heterogeneous cases are occasionally observed [12]. Keeping the importance of these variations in mind in the Puducherry population, present study was undertaken to find out the morphological patterns of the lumbrical muscles and their anatomical variations in the hands and to discuss their clinical implications. This information may help not only the anatomists but also the orthopaedics and microvascular surgeons.

MATERIALS AND METHODS

This cross-sectional study was carried out in the Department of Anatomy, Aarupadai Medical College and Hospital, Puducherry, India, from July 2020 to July 2021. For this study, 50 hands (25 right and 25 left) from formalin preserved cadavers of people of both sexes and ages between 45 and 65 years were used. Hands were labelled 1-25 with R (right), L (left), M (male), and F (female), indicating side and sex. The study was conducted during a routine dissection for first-year medical students in the Anatomy Department.

Inclusion criteria: Normal adult human hands without any apparent damage were included in the study.

Exclusion criteria: Abnormal human hands with gross pathological deformities such as swan-neck deformity, boutonnière deformity, Dupuytren contracture and damaged specimens were excluded from the study.

Study Procedure

For the dissection [13], Cunningham's Manual of Practical Anatomy was used and all the methods were followed in line with international ethics and values [13]. A longitudinal incision was made as per the standard dissection technique from the distal end of the flexor retinaculum to the middle finger's MCP joint level. The palmar aponeurosis, superficial fascia, deep fascia, and slips running from its boundary to each finger were dissected and reflected. The median nerve branches and superficial palmar arch tendons of the FDP were all retracted. The lumbrical muscles were exposed at the distal end of the FDP. The tendons of each lumbrical muscle were traced up to their insertions. The following lumbrical parameters were observed in the present study-Split insertion, Hypertrophied muscle, absence, accessory belly and unipennate. Photographs of the variation of the lumbricals were taken for proper documentation.

STATISTICAL ANALYSIS

Analysis of the data was done using Microsoft excel software 2016.

RESULTS

The present study included 50 hands of both sexes, 25 of the right side and 25 on the left side. The detailed profile of morphological variations in the lumbricals of the hand was observed [Table/Fig-1]. Variations of misplaced insertion were not observed in the present study. Similarly, variations of hypertrophied, unipennate, and accessory belly parameters in lumbrical were observed in one hand. Out of 50 hands, hypertropy of the 1st lumbrical was observed only in a single left-hand specimen [Table/Fig-2]. Among 50 hands, an accessory belly and a normal second lumbrical were observed in a single right-hand specimen [Table/Fig-3]. The third lumbrical was observed normally in 47 out of 50 hands, but three hands (two on the right and one on the left) showed split insertion of the third lumbrical [Table/Fig-4]. The fourth lumbrical showed a unipennate pattern of variations in insertion in one right hand [Table/Fig-5], and the absence of the fourth lumbrical was observed in one left hand [Table/Fig-6]. In the present study, the first and second lumbrical were seen as less variable than the third and fourth lumbricals; the rest of the hands were normal. This study found lumbricals more often at the insertion point than at the origin.

Variations in lumbricals	Right hand n (%)	Left hand n (%)
Normal origin	21 (84)	22 (88)
Spilt insertion of 3rd lumbrical	2 (8)	1 (4)
Hypertrophied 1st lumbrical	0 (0)	1 (4)
Unipennate in 4th lumbrical	1 (4)	0 (0)
Accesory belly on 2nd lumbricals	1 (4)	0 (0)
Absent 4th lumbricals	0 (0)	1 (4)
Total	25 (100)	25 (100)

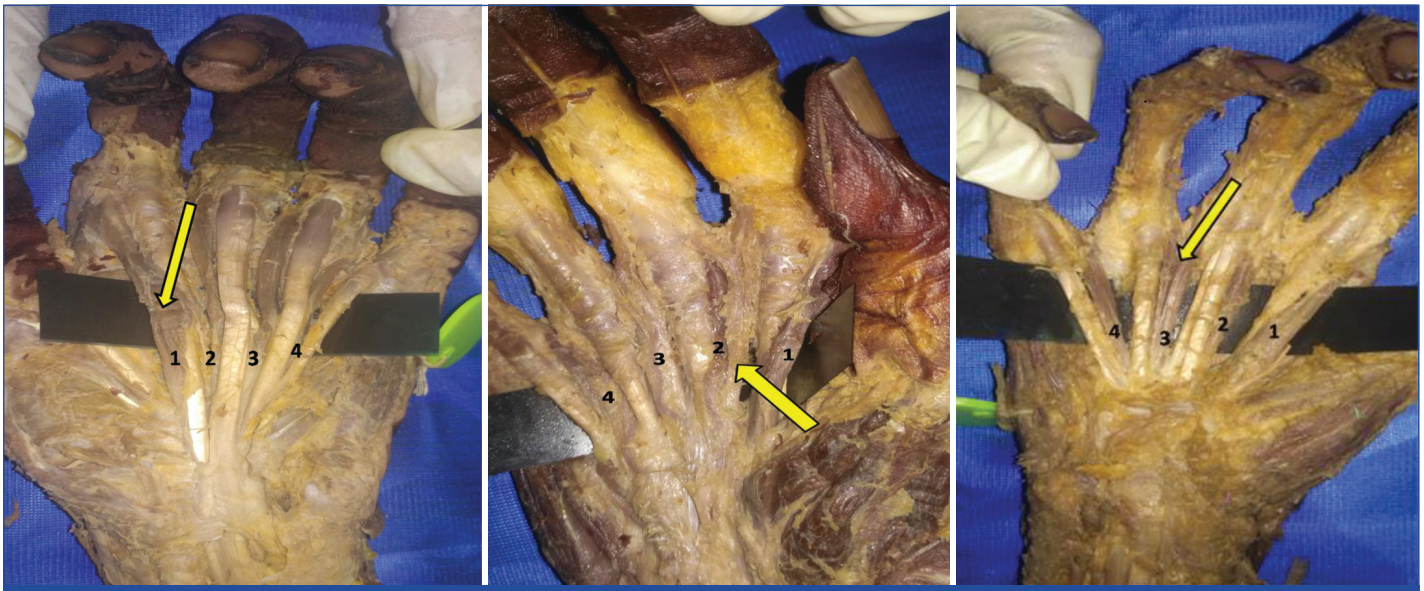
[Table/Fig-1]: Comparison among the lumbricals of right and left hand.

DISCUSSION

The pre-eminent position that man enjoys amongst animals is partly due to the human hand's functional specialisation that can perform intricate and highly skilled precision movements [10]. In comparison to the third and fourth lumbricals, the first and second lumbricals were seen less variable in the current study. According to Mehta HJ and Gardner WU they found that the insertions of lumbricals were more varied than their origins [11]. The third and fourth lumbricals originated from a single tendon rather than two. The lumbricals occasionally originate from the forearm, a metacarpal, or the superficial rather than the deep flexor tendons. Similarly, Perkins RE and Hast MH, reported the first, third, and forearm from flexor pollicis longus [14]. The present study is comparable with the previous studies of workers who reported 100% normal insertion of the first lumbrical [15,16].

Numerous studies indicate that the percentage of second lumbrical bipennate is higher than the lack of muscle. Mehta HJ and Gardner WU observed the bipennate origin of the second lumbrical in 6 out of 75 hands [11]. In addition, Mutalik AM and Ajmani ML reported that the second lumbrical in both hands was bipennate in 3.3% and 24% of cases, respectively [17,18]. Similarly, Koizumi M et al., and Potu B et al., all reported identical observations [19, 20]. Unipennate origin, though rare, has been reported by some workers. The present study found unipennate in the 4th lumbrical variation in 1 (4%) specimen. However, Woods J, observed a unipennate origin in four out of 102 hands [21]. So the present study is comparable to their study.

In the current study, the third lumbrical was seen to have a normal origin and nerve supply in all cases, but split insertions of the third lumbrical were observed in 3 (6%) of the hands, a small disparity may be because of the difference in the number of hands dissected. Similarly, Woods J, also recorded just one split insertion out of 72 hands [21]. Even though it is uncommon, several clinicians have documented split insertion of the second lumbrical. Mehta HJ and Gardner WU have made similar reports of split-second lumbrical



[Table/Fig-2]: Shows hypertrophied first lumbrical. 1-First lumbrical, 2-Second lumbrical, 3-Third lumbrical, 4-Fourth lumbrical. **[Table/Fig-3]:** Shows an accessory belly present along with the normal. 2nd lumbricals: 1-First lumbrical, 2-Second lumbrical, 3-Third lumbrical, 4-Fourth lumbrical. **[Table/Fig-4]:** Shows split insertions of 3rd lumbrical. 1-First lumbrical, 2-Second lumbrical, 3-Third lumbrical, 4-Fourth lumbrical. (Images from left to right)

[Table/Fig-5]: Shows 4th lumbrical demonstrates unipennate origin. 1-First lumbrical, 2-Second lumbrical, 3-Third lumbrical, 4-Fourth lumbrical.

[Table/Fig-6]: Shows the absence of the 4th lumbricales. 1-First lumbrical, 2-Second lumbrical, 3-Third lumbrical, 4-Fourth lumbrical.

insertion in one out of 75 cases [11]. Eyler Don LK and Markee EJ also observed that the second lumbrical were normally inserted [15].

A present study on the variations in the lumbricals found that the absence of the fourth lumbrical was shown in 4% of cases, which is following another study by Mutalik AM that revealed 1.4% and 5.3% of cases to have an absence of the fourth lumbrical on variations in the lumbricals [17]. In the present study, accessory belly on 2nd lumbrical was noted in one out of 50 hands, which is phylogenetically significant. Its occurrence may compress the median nerve in the carpal tunnel. Compressing the median nerve, an abnormally large and additional lumbrical muscle, can cause carpal tunnel syndrome [22]. Similar observations have been reported by Potu B et al., noted the proximal border of the flexor retinaculum as the location of the accessory belly of the second lumbrical, which arises from the ulnar side of the FDP tendon for the index finger [20]. The present study noticed the accessory belly of the first lumbrical, variation of hypertrophied, unipennate and accessory belly parameters in the lumbrical. In contrast, Sawant SP has recorded an additional origin for the first lumbrical accessory belly from the radial side of the tendon index finger of FDP [23].

The present study noticed that out of 50 hands, hypertropy of the 1st lumbrical was observed in a single left-hand specimen. A similar finding by Hosapatna M et al., noted, initial lumbrical hypertrophy in 3.3% may be linked to misusing the thenar muscles due to small motions involving the thumb and index finger [24]. Such lumbrical variations might exhibit a variety of clinical manifestations, including compression of neurovascular structures as in hypertrophy, carpal tunnel syndrome as in the proximal origin and accessory belly of lumbrical [15]. Misplaced insertions, such as when the lumbrical is placed on the ulnar side of the neighbouring extensor expansion, are also relatively frequent [21]. The misplaced insertion's origin and importance are poorly known. According to Cruveilhier J, the third lumbrical should be inserted normally; however, it was misplaced in EE2 (extensor expansion of the middle finger). Functional consequences might result from these changes [25].

[Table/Fig-7] compares the occurrence of split insertion of the third lumbrical with the previous studies [7,11,15,17,21,26]. A comparison of the variation of hypertrophied, unipennate, and accessory belly parameters in lumbrical with previous authors is shown in [Table/Fig-8] [20,21,23,24]. In the present study, variations of misplaced insertion of lumbrical were not observed when compared with other studies, which are shown in [Table/Fig-9] [7,11,17,26].

Workers	Place of the study	Total no. hands	2nd Lumbrical	3rd Lumbrical	4th Lumbrical
Basu SS and Hazary S, (1960) [7]	New York	72	2 (2.8%)	15 (20.8%)	8 (11.2%)
Mehta HJ and Gardner WU (1961) [11]	New York	75	1 (1.3%)	29 (38.7%)	6 (8%)
Eyler Don LK and Markee EJ, (1954) [15]	North Carolina	33	-	5 (15.6%)	2 (6.6%)
Mutalik AM (2011) [17]	India	60	-	7 (13.3%)	1 (1.66%)
Woods J (1968) [21]	London	102	1 (1.3%)	-	-
Singh G et al., (2001) [26]	Singapore	105	-	29 (27.1%)	27 (25.2%)
Present study	India	50	-	3 (6%)	-

[Table/Fig-7]: Comparison of occurrence of split insertion of third lumbrical with the previous studies [7,11,15,17,21,26].

Workers	Total number of hands (n)	Variations	Present study
Potu B et al., (2006) [20]	10	Accessory belly in 2nd lumbrical (10%)	1 right hand in 50 hands (4%)
Woods J (1968) [21]	102	Unipenneate 4th lumbrical in 4 specimens (3.3%)	1 right hand in 50 hands (4%)
Sawant SP (2013) [23]	100	Accessory belly in 1st lumbrical in 5 specimens (5%)	1 right hand in 50 hands (4%)
Hosapatna M et al., (2013) [24]	30	1st hypertropihed left hand (3.35%)	1 left hand in 50 hands (4%)

[Table/Fig-8]: A comparison study of the variation of hypertrophied, unipennate and accessory belly parameters in lumbrical with previous authors [20,21,23,24].

Workers	Place of the study	Total number of hands (n)	2nd Lumbrical n (%)	3rd Lumbrical n (%)	4th Lumbrical n (%)
Basu SS and Hazary S (1960) [7]	New York	72	-	9 (12.5%)	4 (5.6%)
Mehta HJ and Gardner WU (1961) [11]	New York	75	-	7 (9.3%)	6 (8%)
Mutalik AM (2011) [17]	India	60	-	1 (1.66%)	5 (9.95%)
Singh G et al., (2001) [26]	Singapore	107	-	2 (1.86%)	10 (9.34%)
Present study	India	50	-	-	-

[Table/Fig-9]: A comparison study of misplaced insertion lumbrical with previous authors [7,11,17,26].

Limitation(s)

A limitation of the current study was the small number of cadaver hand specimens.

CONCLUSION(S)

The prevalence of variation in lumbricals was reported to be 14% in the present study. The variation was more noticeable in the right hand than the left hand. Split insertion of 3rd lumbrical was one of the variations often seen. Out of 50 hands, 4% had a unipennate pattern of 4th lumbrical and hypertrophied 1st lumbrical. Identifying such variations is important for preoperative diagnostics and hand surgery. Although preoperative diagnosis may be challenging, the practitioner must be constantly alert to such possibilities.

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REFERENCES

[1] Standring S, Borley NR, Gray H. Gray's anatomy: The anatomical basis of clinical practice. Elsevier; 2008.
[2] Nayak SR, Rathan R, Chauhan R, Krishnamurthy A, Prabhu LV. An additional muscle belly of the first lumbrical muscle. Cases Journal. 2008;1(1):01-02.
[3] Hur MS. Variations of the lumbrical muscles in hands of Koreans. Korean J Phys Anthr. 2015;28(4):205.
[4] Kaur N, Kullar JS, Singla RK. Variations in nerve supply of lumbricals of hand in North Indian population. Indian J Clin Anat Physiol. 2016;3(4):467.
[5] Netter F. Atlas of Human Anatomy. Philadelphia, PA: Saunders; 2014.
[6] Palastanga N, Soames R. Anatomy and human movement: Structure and function. Churchill Livingstone; 2012.
[7] Basu SS, Hazary S. Variations of the lumbrical muscles of the hand. Anat Rec. 1960;136(4):501-04.
[8] Ditsios K, Konstantinou P, Pinto I, Karavelis A, Kostretzis L. Extensor mechanism's anatomy at the metacarpophalangeal joint. MOJ Orthop Rheumatol. 2017;8(4):0031.
[9] Standring S. Two drawings by Franz Batke in gray's anatomy. Clin Anat. 2012;25(7):911.
[10] Afroze MKH, Aswinpraksh, Ramesh P, Vaithianathan G, Balaji TK, Judson JP. Variation in innervation of lumbricals of hand. Int J Innov Res & Dev. 2014;3(5):243-46.
[11] Mehta HJ, Gardner WU. A study of lumbrical muscles in the human hand. Am J Anat 1961;109(3):227-38.
[12] Sharrak S, Das JM. Hand nerve compression syndromes. In: StatPearls. StatPearls Publishing; 2021.
[13] Cunningham's Manual of Practical Anatomy Volume 2 Thorax and Abdomen. Scott Med J. 1969;14(11):403-403.
[14] Perkins RE, Hast MH. Common variations in muscles & tendons of the human hand. Clin Anat. 1993;6:226-31.
[15] Eyler Don LK, Markee EJ. The Anatomy & function of intrinsic musculature of the fingers. Bone Joint Surg. 1954;36:01-09.
[16] Joshi S, Joshi S, Athavale S. Lumbrical muscles and carpal tunnel. J Anat Soc India. 2005;54:12-15.
[17] Mutalik AM. Morphological variations in the origin and insertion of lumbricals of the upper limb in cadavers. J Clinic Diag Res. 2011;5(2):278-81.
[18] Ajmani ML. Morphological variations of lumbrical muscles in the human hand with some observations on its nerve supply. Iran Red Crescent Med J. 2001;3:20-25.
[19] Koizumi M, Kawai K, Honma S, Kodama K. Anomalous lumbrical muscles arising from the deep surface of flexor digitorum superficialis muscles in man. Ann Anat. 2002;184(4):387-92.
[20] Potu B, Gorantla PT, Rao M, Vollala V, Nayak S. Anomalous origin of the first lumbrical in the hand and its possible role in carpal tunnel syndrome. Internet J Neurol. 2006;8(1):01-03.
[21] Woods J. Variations in Human myology observed during the winter season of (1867-1868) at Kings College, London. Variations in Human Myology. 1968;16(17):483-85.
[22] Chaudruc JM, Fiorenza F, Rivière C, Arnaud JP. White finger and hypertrophy of the lumbrical muscles. Chir Main. 2000;19(4):232-34.
[23] Sawant SP. The cadaveric study of lumbricals of hand in 100 specimens. Int J Curr Sci. 2013;6E:107-10.
[24] Hosapatna M, Bangera H, Kumar N, Sumalatha S. Morphological variations in lumbricals of hand-a cadaveric study. Plast Surg Int. 2013;23.
[25] Cruveilhier J. The anatomy of human body. New York: Harper Brothers; 1853.
[26] Singh G, Bay BH, Yip GW, Tay S. Lumbrical muscle with an additional origin in the forearm: Lumbrical muscle with forearm origin. Anz J Surg. 2001;71(5):301-02.

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