Journal of Morphological Sciences
J Morphol Sci
Brazilian Society of Anatomy

Original Article
J Morphol Sci 2022;39:217-221

Morphological Study of Variation of Lumbrical Muscles of Hand and its Clinical Importance

Supriya Jainapur[1], G.F Mavishettar[2], Tintu Thottiyil Sukumaran[1], Nanditha Pavikuttan[1], Minnie Pillay[1]

[1]Department of Anatomy, Amrita School of Medicine, AIMS, Amrita Vishwa Vidyapeetham, Ponekkara P.O, Kochi- 682041, Kerala
[2]Department of Anatomy, J.J.M Medical college, Davangere, Karnataka

Disclose and conflicts of interest: none to be declared by all authors

ABSTRACT

Introduction: anomalous lumbrical muscles can cause compression of neurovascular structures in the palm. Variant lumbrical muscles extending into the carpal tunnel, especially those associated with auxiliary tendons, have significant clinical relevance due to their association with carpal tunnel syndrome.

Materials and Method: the present study was carried out to assess the morphology and innervation of lumbrical muscles. Lumbrical muscles were studied in 40 adult human cadaveric hands (34 male & 6 female) of 20 cadavers by dissection.

Results: the first lumbrical showed hypertrophy and origin extending to the proximal border of flexor retinaculum in 1(2.5%) hand. The first lumbrical showed variation in insertion in 2 hands (5%) and third lumbrical in 2 hands (5%), fourth lumbrical in 6 hands (15%). The third lumbrical showed 15% variation in innervation. The second lumbrical was bipennate in 7 hands (17.5%). The third lumbrical was unipennate in 3 hands (7.5%) and was absent in 1 hand (2.5%). The fourth lumbrical was unipennate in 4 hands (10%) and was absent in 2hands (5%).

Conclusion: these unusual variations have wide range of clinical implications. Hypertrophy of lumbricals can cause the compression of branches of radial and ulnar arteries of fingers leading to chronic subischemia. Therefore, it is imperative that clinicians and hand surgeons be aware of such variations during various surgical procedures of hand.

Keywords: Unipennate; Bipennate; Lumbrical muscles; Carpal tunnel syndrome; Chronic subischemia.

Introduction

The hand is a prehensile organ. It is endowed with grasping and precision of movements for skilled work, and it act as a chief tactile apparatus. This is contributed by higher degree of neuro-muscular coordination and a large cortical representation of hand in the sensory and motor cortex of brain. Hence, philosophically it may be said that action of lumbricals of hand are indices of civilization of race[1]. The lumbricals of hand are four small fasciculi which arise from the tendons of flexor digitorum profundus. The lumbricals producing flexion at metacarpophalangeal joints and extension at interphalangeal joints help in various object manipulating skills like writing, stitching and other kinds of precision work. So human hand is revolution in evolution[1]. Lumbricals show variations in their origin, insertion, and innervation. Study of motor balance around the digits is not only fascinating but also most rewarding as it leads to better understanding of the changes caused by selective paralysis[3]. An aberrant lumbrical muscle with abnormal origin and insertion may be the principal cause for compatodactyly. The study of innervation of lumbricals helps to know the aetiology in the paralysis of the muscle and electrical stimulation, physiotherapy and plastic reconstruction in leprosy[4]. The proximal attachment of lumbricals, especially first and second, may predispose to the development of carpal tunnel syndrome in those individuals whose occupation requires repetitive finger movements[5]. Because of increased hand injuries in road traffic accidents, knowledge about the attachments and innervation of lumbricals is very important for the hand surgeons. The present study is undertaken to observe and record the origin, insertion, and innervation of lumbricals in 20 Indian cadaveric hands. These findings will be useful for hand surgeons.

Material and Methods

The study was done on 40 upper limbs of 20 cadavers (17 male and 3 female) of age ranging from 60 to 80 years. These cadavers were used for routine dissection by the medical students. The deformed hands were excluded from the study. The lumbricals were dissected and exposed as per the instructions in Cunningham's Manual of Practical Anatomy, Volume 1[6]. The lumbrical muscles were observed for variations in their morphology, attachments and innervation and photographs were taken.

Results

Out of 40 upper limbs of 20 cadavers (17 male & 6 female) one case had proximal origin (Figure 1). 17 cases had variations in morphology (Table 1) (Figure 2), and 10 specimens had variations in the pattern of insertion

DOI: 10.51929/jms.39.217.2022
ISSN 2177-0298

of lumbrical muscles (Figure 3) (Table 2) and 6 cases presented with variations in the innervation (Figure 4) (Table 3).

Figure 1. Right hand of male cadaver showing proximal origin of first lumbrical muscle (* = Proximal origin of 1st lumbrical muscle).

Table 1. Showing variations in the morphology of lumbrical muscles.

Various patterns of Morphology	First lumbrical	Second lumbrical	Third lumbrical	Fourth lumbrical
Normal type	40 (100%)	33 (82.5%)	37 (92.5%)	36 (90%)
Unipennate	40 (100%)	33 (82.5%)	3 (7.5%)	4 (10%)
Bipennate	0	7 (17.5%)	37 (92.5%)	36 (90%)
Absent	0	0	1 (2.5%)	2 (5%)

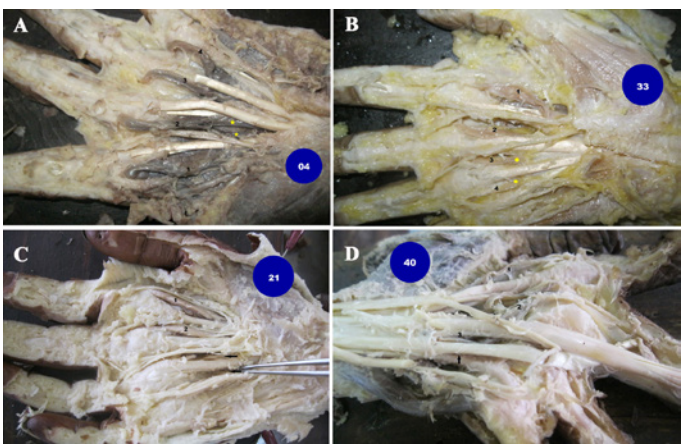

Figure 2. Variations in the morphology of lumbrical muscles, A: Left hand of male cadaver with bipennate 2nd lumbrical (* = 2nd bipennate lumbrical), B: Right hand of female cadaver showing unipennate 3rd & 4th lumbricals (* = 3rd & 4th unipennate lumbricals), C: Right hand of male cadaver with absent 3rd & 4th lumbricals (← = absent 3rd & 4th lumbricals), D: Right hand of male cadaver with absent 4th lumbrical (← = absent 4th lumbrical).

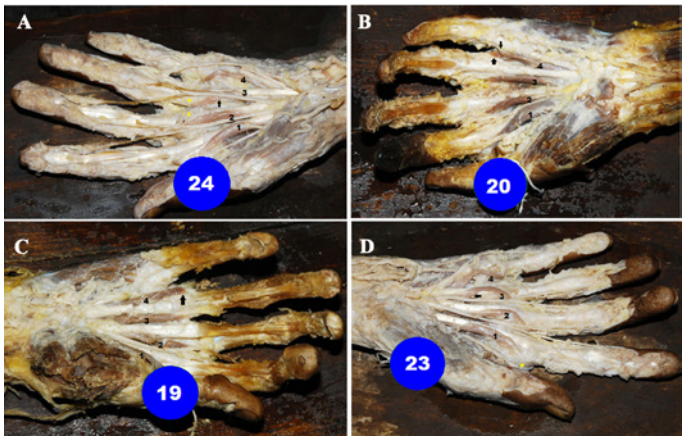

Figure 3. Showing the variations in the insertion of lumbrical muscles. A: Left hand of male cadaver showing split insertion 3rd lumbrical muscle (** = split insertion of 3rd lumbrical), B: Split insertion of 4th lumbrical was observed in the left hand of female cadaver (← = split insertion of 4th lumbrical), C: Female cadaver with misplaced insertion of 4th lumbrical in the right hand (← = misplaced insertion of 4th lumbrical), D: Right hand of male cadaver showing insertion of 1st lumbrical into the base of the proximal phalanx and extensor expansion (*: Insertion of 1st lumbrical).

Table 2. Showing the variations in the insertion of lumbricals.

Various patterns of insertion	First lumbrical	Second lumbrical	Third lumbrical	Fourth lumbrical
Normal type	38 (95%)	40(100%)	38 (95%)	34 (85%)
Split insertion	0	0	2 (5%)	2 (5%)
Misplaced insertion	0	0	0	1 (2.5%)
Extensor expansion and base of proximal phalanx	2 (5%)	0	0	0
Proximal phalanx	0	0	0	3 (7.5%)

Figure 4. The 3rd lumbrical of left hand of male cadaver was supplied by median nerve (← = 3rd lumbrical muscle).

Table 3. Showing variations in the innervation of the lumbrical muscles.

Various patterns of Morphology	First lumbrical	Second lumbrical	Third lumbrical	Fourth lumbrical
Normal type	40 (100%)	40 (100%)	34 (85%)	40 (100%)
Median nerve	40 (100%)	40 (100%)	6 (15%)	0
Deep branch of ulnar nerve	0	0	40 (100%)	40 (100%)
Both median nerve and ulnar nerve	0	0	6 (15%)	0

Discussion

Anatomically lumbricals are highly specialized in their architectural properties with a small physiological cross-sectional area but long fibre length. Their unique properties indicate that they are important in fast alternating and fine-tuning movements of the digits[1]. Lumbricals as a part of the intrinsic musculature are important for its fine movements of the digits. They are quite unique as they connect the flexors of the digits to the extensors. Variations in the origin and insertion of the lumbricals are common[7].

In the present study, in one right hand of the male cadaver, (2.5%) the first lumbrical was bulkier (Figure 1), and the origin extended to the proximal border of flexor retinaculum. Similar observation has been made by other authors as well[8,9]. Shimizu *et al* reported a case of a patient who had carpal tunnel syndrome with triggering wrist caused by hypertrophy of a lumbrical muscle and tenosynovitis due to overuse from heavy labor. The patient showed a characteristic symptom that the numbness became worse with a snapping phenomenon at the carpal area when flexing the fingers[10]. Hypertrophy of the lumbrical muscles can cause the compression of radial and ulnar arteries of the fingers and is likely to cause chronic subischemia[11].

In the present study first lumbrical muscle was unipennate in all the hands. Other authors reported cases of bipennate first lumbrical[11,12]. Vaidya *et al* observed an accessory belly of first lumbrical originating from the radial side of the most radial tendon of the flexor digitorum profundus. This additional slip was fleshy in the middle, while it was tendinous at both the ends[13].

Second lumbrical was bipennate and took origin from the adjacent sides of profundus tendons of the index and middle fingers (Figure 2A) in 7 hands (17.5%) in seven different cadavers in the current study. Other authors also have reported bipennate second lumbrical muscle[8, 9].

The 3rd lumbrical was unipennate arising from the ulnar side of profundus tendons of middle finger (Figure 2B) in 3 (7.5%) hands belonging to three different cadavers. The unipennate 3rdlumbrical has also been reported by other authors in the literature[9,14].

In the present study, fourth lumbrical was unipennate arising from the ulnar side of profundus tendons of ring finger (Figure 2B) in 4 hands (10%) in four different cadavers. Other authors also noted unipennate fourth lumbrical muscle[9,14].

In the present study third lumbrical was absent (Figure 2C) in 1 hand (2.5%) Hospatna *et al* mentioned in their study on 60 hands that third lumbrical was absent in 1(1.6%) hand[15].

In the present study the fourth lumbrical was absent (Figure 2C,2D) in 2 hands (5%) in two different cadavers. In the previous studies other authors also noted absent fourth lumbrical muscle[5]. Priyadarshini *et al* noted a case of bilateral absence of third and fourth lumbrical during routine dissection[16].

In the present study, first lumbrical muscle showed variation in insertion in 2 hands in two different cadavers (5%) (Figure 3D) and in both cases were inserted to the base of proximal phalanx and extensor expansion of index finger.

Third lumbrical showed split insertion in 2 hands in different cadavers (5%)., (Figure 3A). The spit insertion means the muscle tendon was bifurcated, one tendon joining dorsal digital expansion of middle finger and other tendon joining the ring finger. Spit insertion was also observed by other authors[8,9].

Variations observed in the fourth lumbrical included split insertion in 2 (5%) (Figure 3B) hands of two different cadavers as reported by other authors too[8,9]. Fourth lumbrical showed misplaced insertion (tendon of fourth lumbrical was inserted into ulnar side of dorsal digital expansion of ring finger) (Figure 3C), in 1(2.5%) hand. Other authors too have reported the same[8,9]. In 3 hands (7.5%) third lumbrical muscle showed insertion into proximal phalanx in three different cadavers.

In the present study, the third lumbrical showed variation in innervation. It was supplied by both median and deep branch of ulnar nerves (Figure 4) in 6 (1.5%) hands in six different cadavers. Such variation has been observed in previous studies[17,18]. Green *et al* observed that the third lumbrical had dual innervation in 50% of upper extremities. In such cases claw hand deformity affected only little finger[4].

Mainderkar *et al* studied the length of lumbrical muscles in 50 cadaveric hands and noted that length of lumbrical is more in male hands than female hands. It is especially useful in surgeries where the lumbrical muscles, especially the 1st and 2nd lumbricals, are used as muscle flaps for the coverage of the median nerve and its palmar branches. They are also helpful in studying pathogenesis of carpal tunnel syndrome[19].

Development of the hand begins with flattening of the distal upper extremity buds around days 34-38 of embryonic development. Somites form the

limb musculature while mesenchyme of the lateral plate mesoderm forms bone and cartilage. Somatic mesoderm of the hand divides into superficial and deep layers, with the superficial muscles developing earlier than deep muscles. The lumbrical muscles originate from the deep layer of this mesoderm, and by the twelfth week of development, tendons are fully developed and functional[20].

Lumbricals also have evolutionary importance, Haines studied flexor muscles of the forearm and hand in the mammals and lizards; he suggested that the FDS in mammals is homologous with the intrinsic muscles of the palm, and that it shifts its origin proximally in forearm[21]. Furthermore, Koizumi *et al* mentioned that the first lumbrical muscle and the distal muscle belly for the index finger of the FDS have an intimate relationship with each other and have a common phylogenetic origin[22].

Evolutionary considerations also support the idea that the lumbricals may have more of a sensory role than a motor function. The decrease in the relative size of the lumbrical muscle between chimpanzees and humans suggests a decrease in strength of this muscle. The increase in the number of spindle fibres in the lumbrical muscles from non-primate mammals to primates to humans also suggests an increase in the proprioceptive ability of the lumbrical muscle. The decrease in size and increase in the number of spindle fibres could be related to the change in use of the forelimbs from primarily locomotion in non-primate mammals towards feeding in some primates, and finally to tool use and precision manipulation of objects in humans[23].

Conclusion

The anatomical variations of lumbricals are important not only to anatomists, but also to orthopaedic surgeons, physiotherapists and radiologists. In the present study, though we observed presence of lumbricals with their normal attachment and morphology in majority of cases, a rare variations like their high origin, bipennate second lumbrical, unipennate third and fourth lumbricals and also absence of third and fourth lumbricals and hypertrophied lumbricals along with variant nerve supply were observed. These unusual variations have wide range of clinical applications. Anomalous and additional lumbrical muscle can cause carpal tunnel syndrome by compressing the median nerve. Hypertrophy of the lumbricals could compress the radial and ulnar arteries of the fingers, causing chronic sub ischemia. The lumbrical muscles, especially the 1st and 2nd lumbricals, are used as muscle flaps for the coverage of the median nerve and its palmar branches. The study of innervation of lumbricals helps to know the aetiology in the paralysis of the muscle and electrical stimulation, physiotherapy and plastic reconstruction in leprosy Therefore, clinicians and hand surgeons should be aware of such a variation of lumbricals during various surgical procedures of hand.

References

1. Datta AK. Essentials of Human Anatomy. 4th ed. Kolkata: Current Books International; 2009:84,91.
2. Standring S. Ed. Gray's anatomy – The anatomical basis of clinical practice. 40th ed. Edinburgh: Churchill Livingstone Elsevier; 2008:920-21,892.
3. Marquis J. Reconstructive plastic surgery. Vol. 6, USA: WB Saunders Company; 1977:2962,3128,3129.
4. Green DP, Hotchkiss RN, Pederson WC, Wolfe SW. Green's operative hand surgery. 5th ed. Vol. 2, Elsevier: Churchill Livingstone; 2005:1541,1597, 1167,1948.
5. Joshi SD, Joshi SS, Athavala SA. Lumbrical muscle and carpal tunnel. J Anat Soc India 2005;54:12-15.
6. Romanes GJ. Cunningham's text book of anatomy. 12 th ed. London: Oxford University Press; 1981:339.
7. Bergman Ra, Afifi AK, Miyaucchi R. Compendium of human anatomic variation. Baltimore: Urban and Schwarzenberg; 1988:17.
8. Mutalik AM. Morphological variations in the origin and insertion of lumbricals of the upper limb in cadavers. J Clin Diagnostic Res 2011;5:278-281.
9. Modasiya UP, Master NT, Astik RB, Bissa A. Clinical relevance of morphological variations in origin and insertion of lumbricals of hand in South Gujarat population. Natl J Integr Res Med 2013;4:50-52.
10. Shimizu A, Ikeda M, Kobayashi Y, Saito I, Mochida J. Carpal tunnel syndrome with wrist trigger caused by hypertrophied lumbrical muscle and tenosynovitis. Case Rep Orthop 2015:1-3.
11. Singh G, Bay BH, Yip GW, Tay S. Lumbrical muscle with an additional origin in the forearm. ANZ J Surg 2001;71:301-302.
12. Shantakumar RS, Sirasanagandla SR, Nayak SB, Gadahad MR, Somayaji SN, Kumar N. Multiple tendons of the additional belly of flexor pollicis longus in the carpal tunnel: Embryological perspective and their clinical significance. Forensic Medicine and Anatomy Research 2013;1:70-73.
13. Vaidya AV, Sawant SP, Rizvi S. A Case Report On Double First Lumbrical. Int j adv case reports 2017;4:173-175.
14. Chakravarthi KK. Unusual unilateral muscular variations of the flexor compartment of forearm and hand – A case report. Int J Med Health Sci 2012;1:93-98.
15. Hosapatna M, Bangera H, Kumar N, Sumalatha S, Nitya. Morphological variations in lumbricals of hand – A cadaveric study. Plastic surgery: An International Journal 2013;1:1-7.
16. Priyadarshini NA, Kumar VD, Rajprasath R. Bilateral absence of third and fourth lumbricals: a case report with clinico-evolutionary insight. J Curr Res Sci Med 2018;4:116-118.
17. Afroze KH, Aswinprakash, Ramesh P, Vaithianathan G, Balaji TK, Judson JP. Variation in innervations of lumbricals of hands. Int J Innov Res Dev 2014;3:243-246.
18. Brooks HS. Variations in the Nerve Supply of the Lumbrical Muscles in the Hand and Foot, with some Observations on the Innervation of the Perforating Flexors. J Anat Physiol 1887;21:575-585.
19. Maindarkar VV, Dope SA. Morphometric study of sexual dimorphism in lumbrical muscles in human cadaveric hands. Indian J Clin Anat Physiol 2019;6:331-334.
20. Cole P, Kaufman Y, Hatef DA, Hollier LH. Embryology of the hand and upper extremity. J Craniofac Surg 2009;20:992-995.
21. Haines RW. The flexor muscles of the forearm and hand in lizards and mammals. J Anat 1950;84:13-29.

22. Koizumi M, Kawai K, Honma S, Kodama K. Anomalous lumbrical muscle arising from the deep surface of flexor digitorum superficialis muscle. Ann Anat 2000;184:387-392.

23. Wang K, Mc Glinn EP, Chung KC. A Biomechanical and Evolutionary Perspective on the Function of the Lumbrical Muscle. J Hand Surg 2014;39:149–155.

Mini Curriculum and Author's Contribution

1. Supriya Jainapur - MD Anatomy. Contribution: Effective scientific and intellectual participation for the study, data acquisition, data interpretation, technical procedure, preparation and draft of manuscript, final approval. ORCID: 0000-0001-8851-0352

2. G.F Mavishettar - MD Anatomy. Contribution: Guiding Professor, effective scientific and intellectual participation for the study, data acquisition, data interpretation, technical procedure, preparation and draft of manuscript, final approval, Critical review. ORCID: 0000-0003-4689-2035

3. Tintu Thottiyil Sukumaran - MSc. Medical Anatomy. Contribution: Data interpretation, technical procedure, preparation and draft of manuscript. ORCID: 0000-0003-1045-587X

4. Nanditha Pavikuttan - MD Resident. Contribution: data interpretation, Technical procedure, preparation and draft of manuscript. ORCID: 0000-0001-7404-731X0

5. Minnie Pillay - MSc; PhD. Medical Anatomy. Contribution: Preparation and draft of manuscript, final approval, Critical review. ORCID: 0000-0002-2046-7359

Received: April 8, 2022
Accepted: April 24, 2022

Corresponding author
Minnie Pillay
E-mail: minniepillay@aims.amrita.edu