Motor Innervation of the Short Muscles of the Thumb: Anatomic and Clinical Implications

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Abstract

Background: The motor innervation of the thumb muscles though important for the hand surgeon, yet it is still a subject of debate since median and ulnar nerves play variable roles.

Objectives: To describe the innervation of the short muscles of the thumb and the possible presence of a 1st palmar interosseous muscle. To correlate the variations of innervation to prognostic values in nerve diseases and injuries.

Methods: A dissection of 15 adult embalmed hands was performed. An EMG study on 42 hands of healthy volunteers was done in which the compound muscle action potential and the interference pattern were studied by sampling separate muscles.

Results: In (86.6%) of the dissections the muscular branch of the median nerve was the first branch in the palm. A median-ulnar anastomosis was found in (53.3%) of the dissected hands, demonstrated at different levels. In spite of special attention to reveal a first palmar interosseous muscle, it was not detected as a separate entity. In the EMG study, innervation showed considerable variations. Adductor pollicis did not receive pure median innervation, it received the ulnar nerve in (90.5%) of the cases. Abductor pollicis brevis did not show a pure ulnar supply, it was mainly supplied by median nerve (66.7%). The highest percentage (66.7%) of a mixed innervation was shown in opponens pollicis.

Conclusions: The palmar median-ulnar anastomosis at different levels makes it vulnerable in surgical interventions. The absence of significant laterality in the mode of innervation of specific muscles may help the prognosis of the affected hand from an EMG study done on the contralateral side. The conventional EMG method does not specify the exact innervation of each muscle. From the prognostic point of view if the method used in this study is applied conventionally, the severity of the injury can be expressed in terms of muscles involved. Many muscles received mixed innervation and will retain their function on the long run.

Key words: thenar muscles, motor innervation, EMG

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Introduction

The gripping mechanism of the palm is an important adjunct to manual dexterity. Of the hand digits, the thumb is as important as the rest of the digits. Functionally speaking, the most important movement of the thumb is opposition. Though many thumb muscles participate in this movement, the thenar muscles are chiefly responsible.

The intrinsic muscles of the thumb are quite ill-defined. The name of thenar eminence is as vague as its content: while French and German speaking anatomists describe a superficial (external) thenar, comprising the abductor pollicis brevis, flexor pollicis brevis, opponens pollicis muscles and a deep (internal) one formed by the adductor pollicis, most English-speaking ones accept under the name of thenar only the first three muscles[1].

The 1st palmar interosseous muscle in the thumb is still debatable. some authorities have preferred to regard the 1st palmar interosseous muscle as a deep striation of flexor pollicis brevis[2]. This issue is to be further clarified herein.

In this study, the German speaking anatomists were followed so the short muscles of the thumb are counted as: opponens pollicis, flexor pollicis brevis,

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abductor pollicis brevis, and adductor pollicis. Generally speaking, the former three are supplied by the recurrent branch of the median nerve while adductor pollicis is supplied by the ulnar nerve. However, it is neccessory to qualify this statement. Any of the thenar muscles may receive median, ulnar or dual innervation[1,3-6]. The nerve supply of flexor pollicis brevis muscle is subject to more variation than that of any other muscle in the body[4].

Variations in the course and branches of the recurrent branch of the median nerve were reported[5-7]. Because of its recurrent course, the branch from the median nerve to the thenar muscles is vulnerable to lesions that affect these muscles[6]. Median to ulnar communication constitute sources of error in evaluation of nerve coduction velocity & electromyographical (EMG) study[7].

This study aims to report the source of innervation of the thenar muscles through dissection and EMG study of each muscle separately and correlate that to prognostic values in nerve diseases and injuries.

Subjects and Methods

The electromyographical study was performed on 38 apparently healthy volunteers aged between (30y-60y) from both sexes. In two volunteers the muscles on both sides were tested rendering the total number of the hands examined in this study 42. Direct observation of the innervations of the short muscles of the thumb was performed on 15 adult embalmed cadaveric hands of both sexes. In order to restore the softness and flexibility of cadaveric specimen preserved in formalin, the method of Tschernezky[8] was used.

Dissection steps were performed according to Grant' dissector[9] in order to reveal the muscles and follow the branches of the median and ulnar nerves in the palm.

To reaffirm the source of motor innervation of the short muscles of the thumb and explore variations of innervations an EMG was contemplated. This was performed using DANTEC counterpoint 4-channel electromyography.

The test procedure was explained in brief for each subject in order to alleviate any fear, anxiety or apprehension that may be present in the subject. During the procedure the subjects were lying in a supine position on an examination couch. The room temperature was maintained between (25-28^{o}C) during the test procedures. The compound muscle action potential (CMAP) and EMG interference pattern were studied by sampling the four thenar muscles. In addition to stimulation of the median and ulnar nerves while the recording done from each muscle separately.

The stimulation was done using a bipolar stimulating electrode (DANTEC 13L36), which was placed such that the cathode is closer to the recording electrode[10]. The cathode was placed 2-3 cm proximal to the distal crease on the palmar surface, between the flexor carpi radialis and the palmaris longus tendons for stimulation of the median nerve[11]and just over the flexor carpi ulnaris tendon for stimulation of the ulnar nerve[12].

Recording was done by using concentric needle electrodes (DANTEC 13L50). The subject was grounded by special electrode (DANTEC 13S93) with a 15 mm dimension width, usually located between the stimulation & recording electrodes. Muscles were located according to their contraction in action or resisted action[14].

Results

The muscular (recurrent) branch of the median nerve was a thick short nerve that arose from the median nerve at different levels. In (86.6%) of the dissections, it was the first branch of the median nerve in the palm. It may arise as a terminal branch at the same level as the digital branches. Usually it gives branches to the flexor pollicis brevis either crossing it superficially or passing through the muscle itself. In (6.6%) of the cases, the muscular branch appeared in the carpal tunnel and pierced the flexor retinaculum. Yet in another

(6.6%) it arose as a terminal branch at the same level of digital branches.

Median-ulnar anastomosis in the palm

Dissection revealed a connection between median and ulnar nerves in (53.3%) of the hands. The connection was demonstrated at different levels: In (20%) there was a loop connection in the palm just beneath the distal edge of the flexor retinaculum. In (33.3%) there was a connection between the superficial branches of the ulnar nerve with the digital branches of median nerve. In (6.7%) a twig from the deep branch of the ulnar nerve reached the deep stratum of the flexor pollicis brevis after giving its supply to the adductor pollicis muscle while the twig from the median nerve supplies the superficial stratum of flexor pollicis brevis.

The gross anatomy and attachment of the short muscles of the thumb was identical to that mentioned in all established anatomical literature[13,14]. In spite of special attention to reveal any clue of first palmar interosseous muscle. It was not detected as a separate muscle in all the dissected hands.

Variations in the nerve supply of the thenar muscles

In the EMG study, the nerve supply to the short muscles of the thumb showed considerable variations (Table-1).

It is clear from the table that adductor pollicis muscle did not receive pure median nerve innervation. On the other hand, the abductor pollicis brevis muscle did not show a pure ulnar nerve supply. The highest percentage of a mixed innervation was shown in the opponens pollicis muscle (66.7%). The abductor pollicis brevis muscle was mainly supplied by median nerve (66.7%). The adductor pollicis muscle received mainly the ulnar nerve (90.5%).

Table 1: Variations in the nerve supply of the thenar muscles according to the EMG study

Muscles (N=42)	Pure median nerve supply (%)	Pure ulnar nerve supply (%)	Mixed innervations (%)
Abductor pollicis brevis	28(66.7%)	Zero %	14(33.3%)
Flexor pollicis brevis	12(28.7%)	6(14.3%)	24(57%)
Opponens pollicis	4(9.5%)	10(24%)	28(66.5%)
Adductor pollicis	Zero %	38(90.5%)	4(9.5%)

Laterality in the mode of innervation of the thenar muscles

Tables 2 and 3 show pooled observations of right and left hands respectively. In only two cases, the observations were paired. It should be mentioned that in only two cases, right and left hands were examined in the same subject. It is obvious from the EMG procedure that the maneuver is painful for the subject and can hardly be performed for both right and left hands in the same session.

It is clear that the percentage of the mode of innervation of abductor pollicis brevis is exactly identical. However, numerical variations may be suggested when merely observing the percentage of the mode of innervation of the other three muscles, namely flexor pollicis bervis, opponens pollicis, and adductor pollicis.

Chi-square test[15] did not show statistical significance ($p<0.01$) regarding laterality in the mode of innervation of specific muscles.

Table 2: Variation in the nerve supply of the thenar muscles according to the EMG study in the ***right*** hands (total No. of the hands = 30)

Muscles (right)	Pure median	Pure ulnar	Mixed
Abductor pollicis brevis	20 (66.7%)	0%	10 (33.3%)
Flexor pollicis brevis	12 (40%)	0%	18 (60%)
Opponens pollicis	4 (13.3%)	2(6.7%)	24 (80%)
Adductor pollicis	0%	100%	

Table 3: Variation in the nerve supply of the thenar muscles according to the EMG study in the ***left*** hands (total No. of the hands = 12)

Muscles (left)	Pure median	Pure ulnar	mixed
Abductor pollicis brevis	8(66.7%)	0%	4(33.3%)
Flexor pollicis brevis	2(16.7%)	0%	10(88.3%)
Opponens pollicis	0%	4(33.3%)	8(66.7%)
Adductor pollicis	0%	10(83.3%)	2(16.7%)

Discussion

The unsettled issue of the first palmar interosseous muscle

In spite of careful attention through hand dissection to reveal any clue of the first palmar interosseous muscle, it was not detected as a separate muscle in all the dissected hands. In general, a muscle is considered as a separate entity during dissection when it can be easily separated from its surrounding structures. The epimysium that envelopes a muscle can be regarded as a natural boundary that identifies its independent status. For each muscle identified in this study, a clear cleaving fibrous sheath made separation of muscles unambiguous.

To consider the deep stratum of flexor pollicis brevis as a separate muscle[2] and tag it as the first palmar interosseous is an undesirable assumption. Even though these deep fibers have separate innervations, dual innervations, from the ulnar nerve; it is not a justification to consider them as separate entities.

The human body poses many similar examples as in the case of pectineus muscle (femoral and obturator nerve supply); adductor magnus is yet another example being supplied by the sciatic and obturator nerves; However, neither of these muscles were considered to be two separate entities, but were considered as a composite muscle on the account that no fibrous cleavage was found between its components.

To consider flexor pollicis brevis muscle as a composite muscle on the account of the above mentioned similarities may be more justified than considering it as two separate muscles. Even this, we suppose, is adopted to cheer supporters of four palmar interossei muscles as opposed to the well established four dorsal interossei muscles.

Furthermore, functionally speaking, the palmar interossei adduct the fingers. Thus the thumb requires no palmar interosseous muscle because of the thumb already possessing its own powerful adductor pollicis muscle.

Palmar neural anastomosis: another alert to surgeons

The palmar anastomosis between median and ulnar nerves at different levels especially the anastomosis in the palm beneath the distal edge of the flexor retinaculum makes this anastomosis vulnerable in the surgical interventions, like the carpal tunnel release. Surgery literature[16-18] did not bring this issue to the alert of surgeons operating in the palm field.

The high percentage (53.3%) of the presence of anastomosis and the variation in its location as revealed in this study should be considered by surgeons to be avoided in procedures carried on to decompress carpal tunnel in the carpal tunnel syndrome, drain palmar abscess and to free Dupyturen's contracture.

Variation in the mode of origin of the recurrent branch of the median nerve:

The mode of origin of the recurrent branch of median nerve closely confirm with another study[6] that reported the recurrent branch of median nerve as the first branch in the palm in 83.3% of the cases. This usual position of the motor branch makes it vulnerable in blind median nerve decompression. The surgeon is thus advised to release the retinaculum starting at its proximal edge.

Bilateral identical innervation:

The results of the present study concluded that there was no significant laterality in the mode of innervation of each of the thenar muscles studied. To our knowledge, no literature dealt with this issue. According to current results, it may be said that when one hand is affected by disease or injury of its nerves, an EMG study performed on its lateral counterpart may help the physician to have a better idea about the prognosis of the affected hand since both hands are likely identical regarding the mode of innervation of muscles. If thenar muscles were shown to have a double ulnar and median innervation then an injury of the median nerve will prove less crippling to the thumb of the patient bearing in mind the ulnar nerve compensation especially for flexor pollicis brevis and opponens pollicis (Table-1).

The EMG method used in this study versus conventional EMG study

The conventional EMG method records the compound muscle action potential (CMAP) from the thenar muscles as a bulk. It considers thenar muscles as being supplied by the median nerve. Thus, the conventional method does not specify the exact innervation of each muscle as has been demonstrated in this study.

With the EMG conventional method, to say that a specific nerve was severely or mildly injured, this depends on many observations such as including increased insertion activity, spontaneous activity of positive sharp waves, fibrillation and/or fasciculation potentials and a decrease in the sensory action potential and/or CMAP amplitude. In addition to prolonged latencies and a decrease in the conduction velocity or even absent responses. Yet, in clinical practice, many patients though they suffer a complete injury as revealed in conventional EMG method they can still perform almost normal movements of the thumb and even the bulk of the thenar muscles is affected to a small extent after a considerable time following the injury. This could attract the attention of the electromyographer and may mislead him.

From prognostic point of view if the method used in this study is applied conventionally, the severity of the injury can be expressed in terms of muscles involved. Many muscles as revealed in this study received mixed innervation and will retain their function on the long run.

The possible drawback of the EMG method used in this study may be the multiple painful needle insertion sites. Anatomically speaking, there might be a possible radial artery injury. The radial artery passes into the hand between the two heads of 1st dorsal interosseous muscle then enters the two heads of adductor pollicis to form the deep palmer arch. The penetration of the recording needle to adductor pollicis muscle may jeopardize the radial artery or its branches leading to radial artery injury and bleeding. This problem should be kept in mind though it was not confronted in this study.

Studies to date have been criticized in that volume conduction from adjacent muscles and stimulus spread to adjacent nerves can complicate electrophysiologic interpretation[17]. The use of collision studies may lessen the likelihood of these pitfalls, but it dose not eliminate them[18].

Only anatomic confirmation can be considered definitive.

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