

VARIATIONS IN DISTRIBUTION OF MEDIAN NERVE IN THE HAND AND ITS RELATIONS IN FLEXOR RETINACULUM

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ABSTRACT

BACKGROUND

The study of course and branching pattern of median nerve was done earlier by many researchers. The knowledge of median nerve in the hand got prime importance as it supplies motor and sensory branches to the thenar muscle and volar aspect of the hand. It passes through a restricted space under flexor retinaculum and is liable to get compressed. The nerve undergoes morphological changes under the retinaculum. It also shows variations in the course and distribution in the hand. This study is aimed at avoiding damage to the nerve and its main branches in hand surgeries like traumatic tendon surgeries, reconstructive hand surgeries and decompression procedures for carpal tunnel syndrome.

MATERIALS AND METHODS

Fifty cadaveric human hands were dissected and median nerve were traced after cutting the flexor retinaculum. Branches were identified and photographed and the findings tabulated.

RESULTS

The study of median nerve in fifty cadaveric hands show remarkable variation in the branching pattern. Median nerve shows flattening when it passes under flexor retinaculum. In 88% of hands, median nerve divides into medial and lateral branches distal to the flexor retinaculum, whereas 12% hands show early bifurcation proximal to flexor retinaculum. Thenar branches are given off from the lateral division and have an extraligamentous course in 80% of hands. Subligamentous course of thenar branch was seen in 12% of hands transligamentous course in 8%. Multiple accessory thenar branches were also observed arising from the base of proper digital branch to the thumb. Communicating branches were also observed with ulnar nerve seen in all cases at different sites. The first and second lumbrical muscles were supplied by median nerve, and in 10% hands, third lumbrical was also supplied by median nerve. Multiple thin vascular branches to superficial palmar arch were also observed.

CONCLUSION

This study throws light upon anatomical variations of median nerve while it passes under the flexor retinaculum, proximal to the retinaculum and distal to the retinaculum. Anticipation of such variations were helpful during hand surgeries to avoid iatrogenic damage of the nerve and its branches.

KEYWORDS

Median Nerve, Carpal Tunnel, Flexor Retinaculum, Thenar Branch, Carpal Tunnel Syndrome.

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BACKGROUND

The median nerve is one among the three peripheral nerves supplying the muscles of forearm and hand. It is formed by the fusion of medial and lateral roots of brachial plexus in the axilla and runs downwards along with brachial

artery in the arm and descends downwards into the forearm where it lies deep to flexor digitorum superficialis. About 5cms proximal to flexor retinaculum, it become superficial and enters the carpal tunnel. In the carpal tunnel, it lies anterior to the flexor tendons. Distal to the flexor retinaculum, the nerve flattens and divides into medial and lateral branches, but the mode and level of division varies.¹In majority of cases, it divides into medial and lateral branches. Medial branch gives off two common palmar digital nerves to the adjacent sides of the index and middle finger and adjacent sides of middle and ring finger. Motor innervations to second or sometimes third lumbricals also arises from the common palmar digital nerve. It also gives branches to fibrous flexor sheath and communicating

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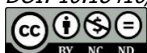
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branches to ulnar digital nerves. The lateral branch first gives off thenar motor branches to thenar muscles and three proper digital nerves for the thumb and lateral side of index finger. The proper digital nerve to index finger gives a branch to first lumbrical. The digital branches also innervate the lateral side of palm, thumb and index finger.

The thenar motor branch shows variation in its course and branching pattern.² Poisel classified it into type 1 extraligamentous, type 2 subligamentous and type 3 transligamentous. Extraligamentous type was the most common type having a recurrent course to enter into the substance of the thenar muscle. The subligamentous type arises within the carpal tunnel and reaches thenar muscle by winding around the distal border of flexor retinaculum. The transligamentous type was given within the flexor retinaculum and pierces it to supply the thenar muscles. This variant is commonly met with hypertrophied thenar muscles and prone to get damaged during carpal tunnel release procedures.

The variations in the course and distribution of median nerve were studied by many authors and its clinical significance with carpal tunnel syndrome was observed.³ Lanz based upon study on 246 hands classified the variations into four groups. Group 1 includes variations in the thenar muscle branch (88.2%), Group 2 having accessory thenar branches (7.3%) arising from distal border of carpal tunnel. Group 3 includes high division of the median nerve associated with persistent median artery. The accessory branches of median nerve arising proximal to carpal tunnel is considered as Group 4. Lindley et al⁴ studied the prevalence of anatomical variations encountered 5.7% out of 526 elective carpal tunnel release. The medial take off of the thenar muscular branch is clinically important and more vulnerable during carpal tunnel release.⁵

Aims and Objectives

The present study aimed at observing the course of median nerve in carpal tunnel, its position in relation with the ulnar bursa and branching pattern with special emphasis to the distribution to the thenar muscles. This study also observed the pattern of distribution of digital branches, communicating branches, vascular branches, cutaneous branches, articular branches and branches to lumbricals and fibrous flexor sheaths. The level of division of common digital nerves and their relations with transverse metacarpal ligaments were also observed. A precise knowledge of the distribution of median nerve in the hand is highly essential during surgical procedures involving tendon repair, carpal tunnel release and vascular surgeries of the hand.

MATERIALS AND METHODS

A total of fifty hands including 4 foetal hands of cadavers from the Department of Anatomy, Government Medical College, Kottayam, Kerala, were subjected to study after getting ethical clearance. The study was extended over a period of two years. Median nerve was exposed in the

forearm and hand. The flexor retinaculum was incised and its measurements were taken. The ulnar and radial bursa were observed. The course of the median nerve in the carpal tunnel and its branching pattern were studied and photographed and subjected to statistical analysis.

Observation

Fifty hands including four foetal hands were subjected to the dissection studies. Median nerve was found to become superficial in the distal part of the forearm approximately 4 cms proximal to the flexor retinaculum. It runs under the flexor retinaculum in front of the lateral aspect of the ulnar bursa in 90% of cases. While in 10% of cases, it runs in front of the middle part of the ulnar bursa. The median nerve was enclosed in a fascial sheath and closely adherent to the under surface of the flexor retinaculum in 10% of cases. It was found that median nerve gets flattened and measures about 4 mm broad while it passes under the retinaculum and it became 5-6 mm broader when it reaches the distal border of flexor retinaculum. The flexor retinaculum having an average measurement of about 3 cms in length and 4.5 mm in thickness. There was not much difference in measurements observed in right and left side.

The palmar cutaneous branch arise from median nerve approximately 2.5 cms from the proximal border of flexor retinaculum in 80% of cases, which supplies the skin over palmar aspect of the hand. In 16% (8 hands), it arises from the median nerve and runs subligamentally along with the median nerve and supplies the skin over the palm (Figure 1). In 4% of hands, the palmar cutaneous branch was absent.



Figure 1. Showing Palmar Cutaneous Branch (PCB) and Subligamentous Thenar Muscular Branch (SLTMB)

The median nerve showed an early division proximal to flexor retinaculum in 6 cases (12%), which includes 4 foetal hands (Figure 2). There was a persistent median artery, which runs in between the bifid median nerve in 2 foetal hands (Figure 3). This artery in turn joins the superficial palmar arch. A subligamentous course of thenar

muscular branch were seen in 2 cases, which showed early division.

The thenar muscular branch which arises from median nerve to supply the thenar muscle showed variation in its origin, course and distribution. In 80% of cases, it arises from the stem of the lateral division of median nerve close to the distal border of the flexor retinaculum (extraligamentous) and enters the substance of thenar musculature and supplying it (Figure 4). The median nerve gives off subligamentous thenar muscular branch, which runs along with the main stem of median nerve under the flexor retinaculum and supplies the thenar muscle at the distal border of the retinaculum in 12% of hands (Figure 5 and 6). A transligamentous thenar muscular branch was observed in 8% of hands (Figure 7), which was shorter and thicker (Table 1 and Chart 1). It arises from the lateral side of the main stem of median nerve under the flexor retinaculum and pierces the flexor retinaculum and enters the substance of the thenar muscle.

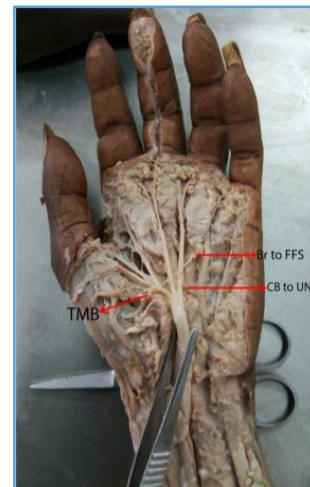


Figure 4. Showing Thenar Muscular Branch (Extraligamentous) and Ulnar Communicating Branch and Branch to Fibrous Flexor Sheath (FFS)

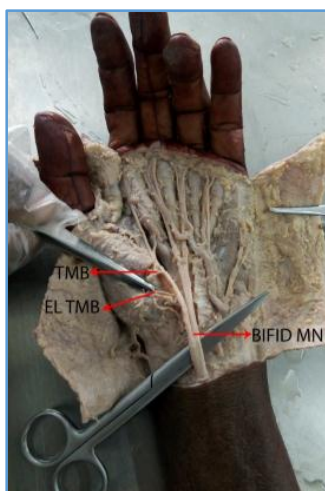


Figure 2. Showing Early Bifurcation (Bifid Median Nerve) and Extraligamentous Thenar Branch (ELTB) and Thenar Muscular Branch (TMB)



Figure 5. Showing Subligamentous Thenar Muscular Branch (SLTMB)

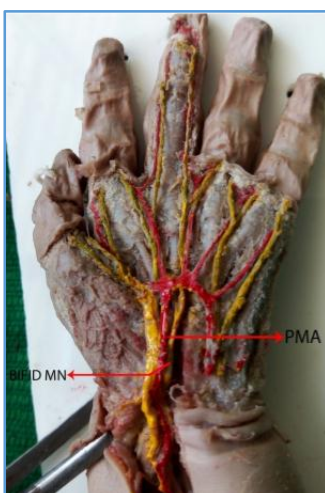


Figure 3. Showing Bifid Median Nerve with Persistent Median Artery (PMA)



Figure 6. Foetal Hand Showing Subligamentous Thenar Muscular Branch Arising from the Medial Division of Bifid Median Nerve

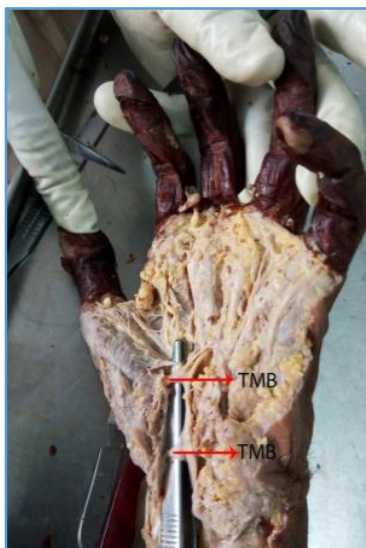


Figure 7. Showing 2 Transligamentous Thenar Muscular Branch

Extraligamentous	Subligamentous	Transligamentous
80%	12%	8%

Table 1. Showing the Level of Origin of Thenar Muscle and Percentage of Cases

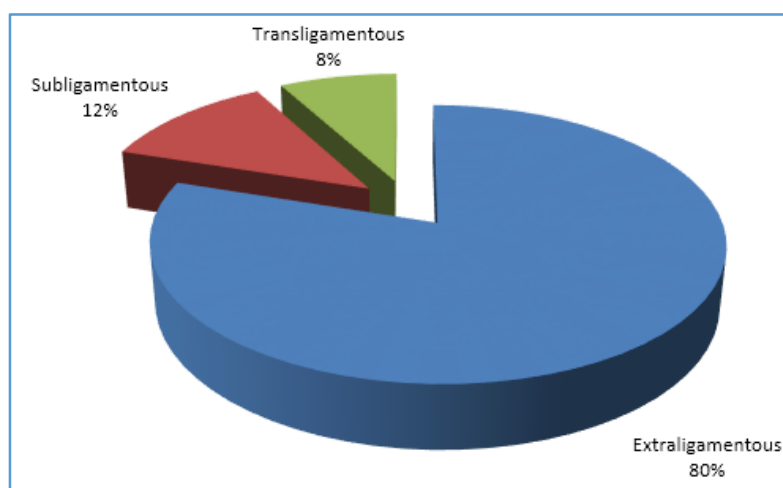


Chart 1. Showing the Level of Origin of Thenar Muscle and Percentage of Cases

Inclusion and Exclusion Criteria

Median nerve on reaching the distal border of the flexor retinaculum divides into lateral and medial division in rest of the 88% of hands, which include right and left sides. The lateral division shows variations in its branching pattern. The stem of the lateral division gives off recurrent thenar muscular branch and later trifurcates into three proper digital branches, two for the thumb and one for the radial side of index finger in 76% (Figure 4). The thenar muscular branch was arising from medial side of lateral division in 2% of cases. The radial digital branch gives off a muscular branch to the first lumbrical muscle and communicating branch to the digital branch of the medial division. The proper digital branches to the thumb also provide accessory thenar branches and also muscular

branches to oblique head of adductor pollicis muscle in two hands 4%. In 12% of cases (6 hands), the lateral division trifurcate first and thenar muscular branch found to arise from the base of the first proper digital nerve to the thumb (Figure 1 and 8). Median nerve at the distal border of the flexor retinaculum bifurcates into medial and lateral division. The lateral division first gives thenar muscular branch, then quadrifurcate into three proper digital nerve for the thumb and index finger and one common digital nerve to supply the adjacent sides of index and middle finger in 4% (Figure 9). It was observed that the median nerve at the distal boarder of the flexor retinaculum divides into five branches (penta-furcation). Three proper digital branches are given to thumb and index finger and two common digital branches in 8% (Figure 10 and Table 2).

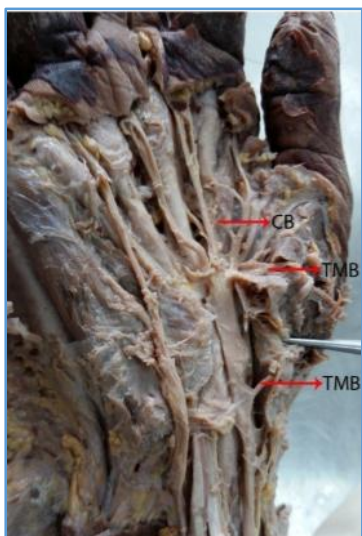


Figure 8. Showing Early Trifurcation of Lateral Division. Multiple Accessory TMB Arising from the First Proper Digital Nerve



Figure 9. Showing Bifurcation of Median Nerve at the Distal End of the Flexor Retinaculum. The Lateral Division Quadrifurcate



Figure 10. Showing Pentafurcation of Median Nerve at the Distal Border of the Flexor Retinaculum and Branch to Hypothenar Muscle from the Median Nerve Under Flexor Retinaculum and Multiple Accessory Thenar Branches

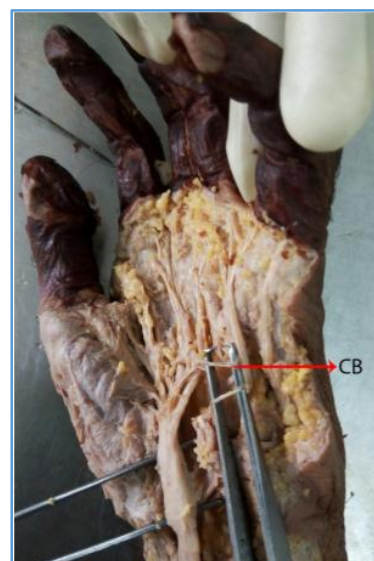


Figure 11. Showing Communicating Branch Between Median Nerve and Ulnar Nerve

Mode Division at the Border of Flexor Retinaculum	Trunk of Median Nerve		Lateral Division		Medial Division	
	No. of Cases	%	No. of Cases	%	No. of Cases	%
Single	0	0	0	0	6	12
Bifurcation	44	88	0	0	44	88
Trifurcation	0	0	38	76	0	0
Quadrifurcation	0	0	2	4	0	0
Pentafurcation	4	8	0	0	0	0

Table 2. Showing Mode of Median Nerve Division

RESULTS

The medial division of the median nerve divides into two common digital arteries and each of them divides into two proper digital arteries at the level of metacarpophalangeal joint in (88%). It was already observed that the medial division gives off to only one common digital branch and all other branches are given off from lateral division in (4%) of hands. The third lumbrical muscle was supplied by the common digital branch of medial division in (10%) of cases. The communicating branches of medial division with ulnar nerve were seen at three sites. In (88%) of cases, it was found between the digital branch of medial division with adjacent digital branch of ulnar nerve (Figure 11 and 12). In (8%) of hands, a separate branch arises from the stem of the median nerve (Figure 11) and turns medially to communicate with the digital branch of the ulnar nerve. The deep branch of ulnar nerve communicate with digital branch of the index finger by piercing adductor pollicis were also found in 4% of cases. There were multiple intercommunications between the digital branches seen in the fingers from proximal to distal phalanx. Multiple vascular branches to palmar arch and cutaneous branch to the skin of the palm were also observed (Figure 13, 14 and 15).



Figure 12. Showing Multiple Communicating Branches between Median Nerve and Ulnar Nerve and Multiple Thenar Branches

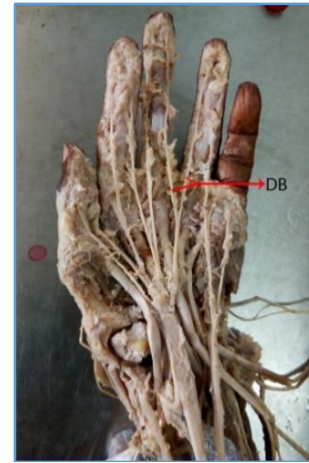


Figure 14. Showing Distribution of Digital Branches and its Intercommunication in Fingers

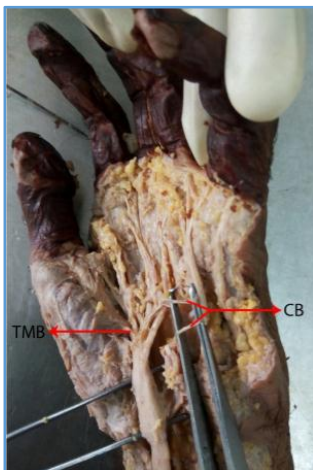


Figure 13. Showing Communicating Branch Between Median Nerve and Ulnar Nerve



Figure 15. Showing Communicating Branches between Median and Ulnar Nerve. Digital Arteries Piercing the Common Digital Nerve of the Median Division

DISCUSSION

The study of the course of median nerve under flexor retinaculum and its distribution in the hand shows remarkable variations. Being superficial at the proximal border of flexor retinaculum, the chances of damage of the nerve is more in wrist injuries. Palmar cutaneous branch runs subligamentally along with the median nerve to reach the palm. Hence, the chances of compression and damage is more in these cases.⁶ The early division of median nerve was seen in 12% of cases of hands can also increase the chance of compression of median nerve and increase the risk for development of carpal tunnel syndrome.⁷

Higher division of median nerve was observed in 6 hands (12%), which was comparatively much higher with the earlier studies. Amadio reported high bifurcation of median nerve in 3.3% hands while doing carpal tunnel release in 275 cases.⁸ Persistent Median Artery (PMA) associate with bifid median nerve was found in 2 foetal hands (4%). Such an association leads to carpal tunnel

syndrome and have chances of injury of this vessel during decompression procedures.⁹The present study variation of median nerve distribution in the hand are classified into 4 groups. According to Lanz classification, group 1 include the variation in the course of Thenar Muscular Branch (TMB) from the lateral division. The most common course of TMB was extraligamentous having prevalence of 80%, transligamentous 8% and subligamentous 12%.The least common course was transligamentous. Group 2 include the accessory thenar branches distal to the flexor retinaculum (54%) arising from the proximal part of the first proper digital nerve and from the stem of the lateral division. Group 3 having early division of median nerve proximal to the flexor retinaculum was found to be 12% and Group 4 in which accessory thenar branches arising proximal to the carpal tunnel was 8%. Theextraligamentous thenar branch arise from the radial side of the stem of lateral division having a recurrent course to reach the muscle is short and thick in 96% of hands and was thinner and longer in 4% of

hands. Thenar branch also arise from medial aspect of the lateral division in 2% of cases was clinically important during CTR procedures, Olave E et al.¹⁰ Accessory thenar branches are multiple and slender, probably proprioceptive in function. The pattern of origin and distribution of thenar muscular branches does not show much variation in right and left hands except in 4% of left hands having extraligamentous, subligamentous thenar branches and multiple accessory thenar branches were seen.

The present study also observed the various pattern of division of the trunk distal to the retinaculum. The main trunk divides into medial and lateral branches and the lateral branch trifurcate in 76% of hands after giving off thenar branch, which appears to run superficially, hence, the chances of damage is more in trivial injuries in this region. Pentafurcation of the trunk were seen in 8% of hands and leads to crowding of branches, so injuries over this region could damage more branches.

The median nerve innervates first and second lumbricals in 90% of cases. Third lumbrical was supplied by the digital branch of median nerve in 10% specimens, which almost coincide with the previous studies where 12% of cases supplied by median nerve.¹¹

The digital branch of median nerve supplies three and half digits in all cases were studied. The digital branches communicate each other of the same digit and also with the adjacent digit. The digital branches also sends articular branches to the joints of fingers and hand and vascular branches to the superficial palmar arch. Communicating branches with digital branches of the ulnar nerve was found in 88% of specimens, whereas communication with the deep branch of the ulnar nerve seen in 4%. A separate branch arise from the stem of the median nerve were seen communicating with digital branch of the ulnar nerve in 8% of hands. These connections may get severed during open or endoscopic carpal tunnel release procedures.¹²

CONCLUSION

The present study which highlights the distribution of median nerve in the hand and its relation in the carpal tunnel reveals the anatomical variations the nerve undergo while it passes through a limited space in the carpal tunnel and hollow of the palm. It is helpful to give awareness to the surgeons during the hand surgeries to avoid damages of this nerve and its branches. The variation in branching pattern and mode of innervations, thenar muscle should be

kept in mind to avoid injuries during various surgical procedures. The prevalence of persistent median artery along with bifid median nerve should also be investigated preoperatively.

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