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Original research article

Study of Surgical Importance of Variations and Branching Pattern of Median Nerve at Carpal Tunnel

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Abstract

Background: Median Nerve is called labourer's nerve as it supplies large flexor muscles of forearm and five intrinsic muscles of hand which help in movement of the thumb. Comprehensive knowledge pertaining to its variations is extremely important in clinical and surgical procedures so as to avoid injury to it. The precise knowledge oflevel of origin of muscular branches of median nerve is essential in free muscular transfers to restore the mobility of fingers after trauma and to understand the variouspresentations of distribution of median nerve.

Material and Methods: The study was done on 51 upper limb human cadaver specimens which were collected from dissection room from Department of Anatomy, at, Patna medical college and Hospital, Patna , Bihar. and these specimens include both adult and viable foetal cadavers, over a period of two years. The specimens obtained were fixed in 10% formalin and were finely dissected.

Conclusion: In the present study an attempt is made to know the possible variations of median nerve branching pattern and termination in carpal tunnel so as to provide additional information which may help to decrease the risk of diagnostic and operative complications.

Keywords: Median Nerve; Carpal Tunnel; Flexor Retinaculum; Carpal Tunnel Syndrome.

Introduction

Carpal tunnel syndrome is a common focal peripheral neuropathy. Increased pressure in the carpal tunnel results in median nerve compression and impaired nerveperfusion, leading to discomfort and paraesthesia in the affected hand.[1] Entrapment of the median nerve in the carpal tunnel is one of the most common entrapment neuropathy syndromes in clinical practice. The main causes of this syndrome include repetitive strain, wrist fracture, rheumatoid arthritis, a space occupying lesion, dialysis related amyloidosis, diabetes mellitus and cases with no apparent cause. It was found that thickening of the synovium or fibrosis was the mostcommon cause of the syndrome. Anatomic variations of the median nerve are frequent and they are significantfor wrist surgery particularly in the treatment of carpal tunnel syndrome. Surgical techniques with short incisions and endoscopic procedures demand a thoroughknowledge of the anatomy and variations of the structures in the wrist. The carpal tunnel has been recognized as a site where multiple anatomical

variations can occur. These variations can involve neural, vascular, tendinous and muscular structures. The anatomy and function of the hand and recovery after injury have been a constant source of interest. As the thumb is the most important digit because of its capacity for opposition, defects or injuries to its innervation interfere with its action and consequently impair the efficiency of the hand as a whole. The normal hand function is the balance between the extrinsic and intrinsic muscles. Much of the importance of the hand is dependent on the action of the thumb. Functionally, the thumb is one half of the hand, which acts in the opposite direction tothe fingers in grasping any object. The thumb mobility is under the control of long and short muscles. The long flexor tendons of the fingers provide the power of the grip, the short intrinsic muscles of the hand are responsible for adjusting the position and carrying out the finer skilled movements of the digits and specialized motion. Carpal tunnel syndrome is a common clinical entity, wherein surgical releaseof the transverse carpal ligament, using endoscopic as well as open procedures is an established treatment method. Surgical decompression of the carpal tunnel requires special caution regarding the anatomic variations of the recurrent motor branch of themedian nerve (RMB) which supplies thenar group of muscles. Any damage to the RMB results in wasting of the thenar muscles with loss of opponence. The loss of opponence is a major handicap especially in dominant hand since it impairs the firmpalmar grip. The carpal tunnel, located on the palmar surface of the wrist, contains the median nerve, four tendons of FDS, four tendons of FDP and the tendon of FPL. Since the nerve passes through the narrow carpal tunnel formed by the TCL and the carpal bones and is crowded by nine flexor tendons in the wrist joint area, it is therefore important for clinicians to recognise the frequency and multiplicity of the anomalous structures and variations within this region, especially the anatomical course of the median nerve and its branches.

Objectives

To study the side of origin of palmar cutaneous branch of median nerve, To study the origin and course of recurrent motor branch of median nerve, To note the accessory thenar branches of median nerve and its level of origin withrespect to flexor retinaculum and site of origin. To note the communication between ulnar nerve and median nerve in hand.

Review of Literature

According to Hollinshead (1958), as the median nerve emerges from behind the lower edge of the flexor retinaculum, median nerve and its branches lie immediately behind the palmar aponeurosis. At about the level of the distal borderof flexor retinaculum the median nerve breaks up into its terminal branches, the exact level of branching varies. In 1961, Mehta and Gardner reported third lumbrical muscle is innervated by themedian nerve in 2 out of 75 hands. In 1968, Papathanassiou et al. observed the division of the median nerve within the carpal tunnel during dissection of a male right hand. The RMB originated from the anteromedial aspect of the lateral trunk, passed laterally and left the carpal tunnel by piercing the flexor retinaculum 6 mm proximal to its distal border. In 1970, Lind burg RM et al. reported an Ac.TBMN in addition to a motor branch which had a normal appearance; an accessory motor branch was arising from median nerve at the proximal end of the carpal tunnel. Both branches were of equal size and both pierced the FR. The normal branch pierced the FR distally. Author advocates the use of an incision parallel to thenar skin crease which affords an excellent view of the median nerve and its branches. Anatomical course of the RMB of the median nerve was studied in ten hands in 1978 by Johnson RK and Shrewsbury MM. In two hands, the branching of mediannerve was seen to occur distal to the distal edge of the transverse carpal ligamentand then ran proximally that is recurrent. In the remaining eight dissections the RMB entered a definite tunnel in TCL.

The RMB passed a short distance distallyfrom its branching within the carpal tunnel before traversing the carpal ligament within a tunnel in the ligament and then passed proximally to terminate within thethenar muscles. In surgical procedures for decompression of median nerve,incision to expose the carpal canal should be judiciously ulnar to thenar flexion crease and one must be aware of the RMB which passes through the carpal tunnelin TCL slightly radial to its mid-line and proximal to the distal edge of TCL. In 2007, Loukas M et al. observed the communicating branches between medianand ulnar nerves in 170 hands (85%) out of 200 formalin fixed hands. Out of which 143 hands (84.1%) belonged to type I (ulnar to median nerve), 12 hands (7.1%) belonged to type II (median to ulnar nerve), 6 hands (3.5%) to type III (multiple, present horizontally) and 9 hands (5.3%) to type IV (mixed type, multiple combinations existed) and concluded that according to origin and distribution of branching patterns of median nerve, they were able to define a riskarea in which the communicating branches may be subjected to iatrogenic injury during hand procedures. Median nerve as per description in most of the established text and reference books gives recurrent motor branch to thenar muscles. Its lesion or injury will cause physical disability affecting the work of person. Median nerve is often injured at the wrist accidentally or in attempted suicide. In such cases, patient is asked to abduct or oppose the thumb against tight resistant, the thenar muscles canbe felt to contract, if nerve is intact.
It is important because of its role in controlling the movements of the thumb which are crucial in the mechanism of gripping by the hand. **At wrist**: Median nerve lies first on the radial side of the superficial flexor tendons and almost directly behind but slightly to the radial side of the palmaris longus tendon. **In the Carpal tunnel:** It lies in front of the ulnar bursa enclosing the flexor tendons and immediately behind the FR. At about distal border of FR the mediannerve divides under cover or distal to retinaculum into medial and lateral trunks. As the digital branches of the median nerve pass distally they typically course behind the superficial palmar arch, but lie at first in front of the long flexor tendons. The proper digital nerve to the radial side of the index finger gives off a twig to the first lumbrical as it passes superficial to this muscle. The common digital nerve to the adjacent sides of the index and middle fingers similarly supplies the second lumbrical.

Material and Methods

The present study was done on 51 upper limb human cadaver specimens. Thespecimens were collected from dissection room from the Department of Anatomy, at Patna Medical College and Hospital, Patna, Bihar. and these specimens include42 adult specimens and 9 viable foetal cadaver upper limb specimens, over a period of two years. The specimens obtained were fixed in 10%formalin and were finely dissected.

Inclusion criteria

Upper limb specimens of human adult and viable foetal cadavers with no previous surgeries in hand region.

Exclusion criteria

Any gross evidence of congenital disorders/surgeries.Muscular anomalies in carpal tunnel.

Collection of Data

The gross dissection was done by following the guidelines of Cunningham's Manual. In the palmar region the following incisions were made. From the middle of the transverse incision at the palmar crease of the wrist, an incision was made along the medial border of the thenar eminence to the tip of thethumb. A longitudinal incision was made from the middle of the transverse incision at theproximal crease of the wrist to the tip of the middle

finger.

To observe the side of origin of palmar cutaneous branch of median nerve.
To observe the origin and course of recurrent motor branch of median nerve. To observe the accessory thenar branches of median nerve and its level of originwith respect to flexor retinaculum and site of origin. To observe the bifurcation/division of the median nerve with respect to flexorretinaculum.

Results

ORIGIN OF PALMAR CUTANEOUS BRANCH OF MEDIANNERVE

Table 1:

Origin of PCBMN	Site of origin	Right		Left	
		N	%	N	%
Single PCBMN	Given from radial side	25	49.01	21	41.17
Multiple PCBMN	Given from radial side	1	1.96	3	5.88
	Given from ulnar side	0	0	1	1.96
Total		26	50.97	25	49.01

Origin of single PCBMN from radial side was seen in 49.01% on right and 41.17% on left side. Multiple PCBMN from radial side was observed in 1.96% on right and 5.88% on left side, whereas only 1.96% was observed on left side from ulnarside of Median Nerve.

PRESENCE OF ACCESSORY THENAR BRANCH OF MEDIANNERVE

Table 2:

accessory thenabranch ofmedian nerve	Right		Left	
	N	%	N	%
Present	12	23.52	14	27.45
Absent 49.01 41.17	14	27.45	11 50.97 49.01	21.56
Total	26	50.97	25	49.01

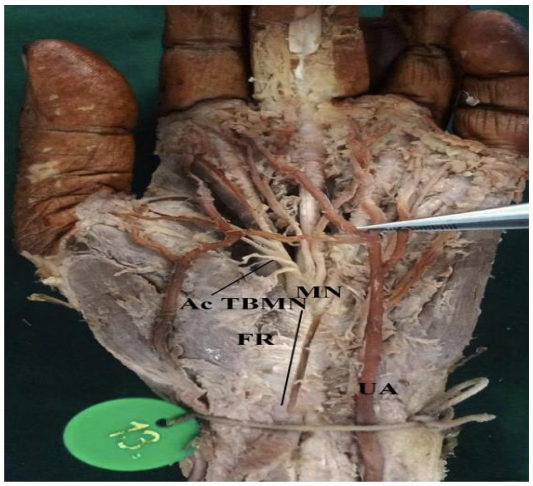
Accessory thenar branch of median nerve is present in 26 specimens (51%)that is 12 (23.5%) on right and 14 (27.4%) on left side

Table 3: LEVEL OF ORIGIN OF ACCESSORY THENAR BRANCH OF MEDIAN NERVE

Level of origin of accessory thenarbranch of median nerve	Right		Left	
	N	%	N	%
Proximal to flexor retinaculum	Nil	Nil	Nil	Nil
Within the retinaculum	05	9.8	02	3.9
Distal to retinaculum	07	13.7	12	23.5
Total	12	23.5	14	27.4

Level of origin of accessory thenar branch of median nerve was observed within the flexor retinaculum in 9.8% on right and 3.9% on left side, distal to flexor retinaculum was

observed in 13.7% on right and 23.5% on left side.



ACCESSORY THENAR BRANCH OF MEDIAN NERVE IS DISTAL TO FLEXOR RETINACULUM

MN - Median nerve

FR - Flexor retinaculum

Ac- TBMN -Accessory Thenar branch of median Nerve

UA - Ulnar Artery

Table 4: ORIGIN OF ACCESSORY THENAR BRANCH OF MEDIANNERVE

Origin of accessory thenar branch of mediannerve	Right		Left	
	N	%	N	%
From the 1st common digital nerve	05	9.8	01	1.96
From the radial proper digital nerve to thumb	07	13.72	13	25.49
Total	12	23.52	14	27.45

Accessory thenar branch of median nerve originated from 1st common digitalnerve in 5 specimens (9.8%) on right, in 1 specimen (1.96%) on left side and it originated from radial proper digital nerve to thumb in 7 specimens (13.72%) on right and in 13 specimens (25.49%) on left side.

Table 5: DIVISION OF MEDIAN NERVE INTO MEDIAL AND LATERAL TRUNKS

Division of Median nerve intomedial and lateral trunks	Right		Left	
	N	%	N	%
Proximal to flexor retinaculum	03	5.88	03	5.88
Within the retinaculum	08	15.68	04	7.84
Distal to retinaculum	15	29.41	18	35.29
Total	26	50.97	25	49.01

Out of 26 right upper limbs, 3 (5.88%) divided into medial and lateral trunksproximal to FR, 8 (15.68%) within the retinaculum and 15 (29.41%) distal toretinaculum. Out of 25 left upper limbs, 3 (5.88%) specimens divided into medial andlateral trunks proximal to flexor retinaculum, 4 (7.84%) within the retinaculum and 18 (35.29) were distal to retinaculum.

Table 6: MEDIAN NERVE SUPPLYING ADDUCTOR POLLICIS MUSCLE

Other variations Observed inMedian Nerve	Right		Left	
	N	%	N	%
cis supplied by mediannerve				

	04	7.8	02	3.9

Adductor pollicis muscle had additional nerve supply form median nerve onright side in 4 specimens (7.8%) and 2 specimens (3.9%) on left side.

Table 7: PRESENCE OF PERSISTENT MEDIAN ARTERY WITHMEDIAN NERVE

Other variations Observed inMedian Nerve	Right		Left	
	N	%	N	%
Persistent median artery with median nerve	01	1.96	01	1.96

Persistent median artery accompanying with median nerve was observed inone specimen (1.96%) each on right and left sides.

Discussion

The importance of branches of median nerve given at and around the carpal tunnel is worth, as they innervate skin over thenar eminence, thenar muscles, lumbricals, cumulatively responsible for the efficiency of the thumb and multiple activities of the hand. In the present study, level of origin of recurrent motor branch of median nervewas Pre-ligamentous in 1.96%, Sub-ligamentous in 19.60% and Extra-ligamentous in78.42% which was statistically significant. This was in accordance with finding of Senanayake et al., Ahn et al., Imamura K, Sacks et al. and Alp M et al. There is possibility of palmar cutaneous nerve damage as a source of painful dysesthesia following surgery for carpal tunnel syndrome. Neuroma of the palmar cutaneous branch of median nerve is a common complication of anterior wrist surgery after carpal tunnel decompression. The palmar cutaneous branch of median nerve is known to be vulnerable in procedures involving the distal forearm and the palms particularly in carpal tunnel release. It is the last branch of median nerve to be givenoff in the forearm. Recurrent motor branch of the median nerve supplying the thenar muscles liessuperficially and may be severed by relatively minor lacerations involving the thenareminence. Severance of the recurrent motor branch of median nerve paralyses the thenar muscles and the thumb looses much of its usefulness. The existence of Trans-ligamentous and Subligamentous variations of the RMB increases the susceptibility to injury during transverse carpal ligament incision for carpal tunnel decompression. The surgeons must look for anatomical variants of TL and SL where the RMB issignificantly at greater risk for iatrogenic injury.

Table 8: Comparison of Communication Between Ulnar and Median Nerve

Studies	N	Ulnar and median nerve communications
Present study	**50**	**15.6%**
Vashistha K[60]	50	20%
Bas et al.[34]	30	67%
Loukas M et al.[51]	200	85%

Communicating branch between ulnar and median nerve originatingproximally from the 4th common digital nerve (from ulnar nerve) and entering the3rd common digital nerve more distally (to median nerve) in hand is called as Berretini anastomosis. These interconnections are at risk when releasing the distal aspect of the TCLduring open or endoscopic carpal tunnel release. Aggressive retraction in this regionand placement of the

endoscope further distal to the TCL should both be avoided in order to prevent traction injury to these nerves resulting in paraesthesia in the long orring finger distribution. These interconnections are at risk when releasing the distal aspect of the TCL during open or endoscopic carpal tunnel release. Aggressive retraction in this region and placement of the endoscope further distal to the TCL should both be avoided in order to prevent traction injury to these nerves resulting in paraesthesia in the long orring finger distribution. The median artery persists into adulthood in two forms. In the antebrachial type which is considered normal, it arises mostly from the anterior interosseous artery and does not reach the palm. The palmar type may arise from any of the forearm arteries and accompanies the median nerve in the carpal tunnel. It usually terminates at the superficial palmar arterial arch or as the main blood supply to the index and long fingers. The term PMA refers to the palmar type of the median artery. When present, the median artery is the main blood supply to the median nerve, corresponding to Types 2 and 3 of vascularization of the median nerve as described by Pecket et al.

Conclusion

In the present study an attempt is made to know the possible variations of median nerve branching pattern and termination in carpal tunnel so as to provide additional information which may help to decrease the risk of diagnostic and operative complications. Such variations of peripheral nerves noticed in routine surgical procedures or in traumatic injuries should be included into the surgical training programmes to help avoiding iatrogenic injuries.

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