

ANATOMICAL STUDY ON THE BRANCHING PATTERN OF THE ULNAR NERVE IN THE WRIST AND PALM

Serin Peter¹, Raniprabha Sukumaran²

¹Associate Professor, Department of Anatomy, Government Medical College, Kottayam, Kerala.

²Assistant Professor, Department of Anatomy, Government Medical College, Kottayam, Kerala.

ABSTRACT

BACKGROUND

Ulnar nerve is one of the main nerves in the upper limb. The distal course of the ulnar nerve in particular has many clinical implications. The deep branch of ulnar nerve supplies most of the intrinsic muscles of hand which are concerned with the fine intricate movements of the hand. Due to this reason, the ulnar nerve is also called the "musician's nerve". Ulnar nerve has a relatively superficial course in the lower part of forearm and wrist which makes it easily prone to injuries. It is also very frequently injured in surgical corrections in the carpal tunnel. A better understanding of the distal course of the nerve will help in preventing and effective correction of such injuries. Therefore, an anatomical study on the branching pattern of the ulnar nerve in the wrist and palm will be of great use to the orthopaedic and vascular surgeons. The aim of this study is to find out the terminal branching pattern of ulnar nerve in the wrist and its extent of supply in the hand.

METHODS

The study was carried out in the Department of Anatomy, Government Medical College, Kottayam by the dissection of 40 upper limb specimens following the routine dissection method. The specimens were obtained after ethical clearance and were embalmed prior to the study. The distal part of ulnar nerve was dissected, its terminal branching pattern and extent of supply in the hand were noted and photographed.

RESULTS

In 29 specimens (72.5%), the termination of ulnar nerve showed a bifurcation pattern where the main trunk divided into a superficial sensory branch and deep motor branch whereas in 11 specimens (27.5%), the nerve was seen terminating in a trifurcation pattern. In 35 specimens (87.5%), the level of termination of ulnar nerve trunk was within the Guyon's canal. In 5 specimens (12.5%), the nerve terminated at higher level before entering the Guyon's canal. In 28/40 specimens superficial terminal branch divided into medial proper and common digital branches. In 12/40 specimens, the nerve divided into proper, common digital branches and a communicating nerve to digital branch of median nerve. In 37 specimens (92.5%), the deep branch of ulnar nerve supplied the medial two lumbricals. In 1 specimen (2.5%), second, third and fourth lumbricals were supplied by the deep branch of ulnar nerve which is an uncommon finding. In 2 specimens (5%), all the four lumbricals were supplied solely by the deep branch of ulnar nerve which is rarely seen. In the present study, 32 specimens (80%) were seen to be supplied by the deep branch of ulnar nerve. In 8 specimens, the muscle was not supplied by the ulnar nerve.

CONCLUSIONS

The site, extent of injury, variations and the delay in treatment significantly influences the outcome of ulnar nerve repair. Thus, an adequate knowledge of all possible variations of the ulnar nerve may be important for clinicians and may help to explain uncommon symptoms.

KEYWORDS

Ulnar Nerve, Superficial Sensory Branch of Ulnar Nerve, Deep Motor Branch of Ulnar Nerve, Guyon's Canal.

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BACKGROUND

Ulnar nerve begins in the axilla from the medial cord of the brachial plexus (C8, T1). It is located medial to the third part

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Corresponding Author:

Dr. Raniprabha S,

Lords Court, N. T. Paul Villa No. 13,

Near Parolickal Junction,

Athirampuzha P. o, Kottayam- 686562, Kerala.

E-mail: drraniprabhavivek@gmail.com

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of axillary artery between it and the vein. At the back of the medial epicondyle, the ulnar nerve is lodged in a groove. It leaves the posterior compartment of the arm to enter the anterior compartment of the forearm between the humeral and ulnar heads of flexor carpi ulnaris.¹ The ulnar nerve travels downwards lying on the flexor digitorum profundus muscle under cover of the flexor carpi ulnaris in the upper third of forearm. In the lower two-thirds of the forearm the ulnar nerve is superficial as lies lateral to the flexor carpi ulnaris tendon. It supplies part of the flexor digitorum profundus that controls the ring and little fingers. Ulnar nerve accompanied by the ulnar artery enters the palm on

the radial side of the pisiform bone and superficial to the flexor retinaculum.

At the wrist, the ulnar nerve passes under the superficial part of the flexor retinaculum (in Guyon’s canal) with the ulnar artery and divides into superficial and deep terminal branches.² Guyon’s canal is a fibro osseous canal approximately 4-cm long in the adult on the anteromedial side of the wrist. Roof is formed by palmar carpal ligament and Palmaris brevis. Floor is formed by transverse carpal and pisohamate ligaments. Canal transmits ulnar nerve and artery with occasional venae comitantes. Ulnar nerve divides within at the level of hook of hamate into a deep radial motor branch and superficial ulnar sensory branch.² Variations in the branching of the ulnar nerve may occur here. Guyon’s canal is another potential site of entrapment neuropathy and the condition is called ulnar tunnel syndrome.³

Exiting the canal, the nerve divides into superficial and deep branches. The superficial branch provides sensation for the ulnar border of the hand including the volar surface of the little and half of the ring fingers. Deep branch carries motor fibers across the palm of the hand together with the deep palmar arch of ulnar artery. It gives branches to all four hyposthenia muscles, two ulnar lumbricals and all interosseous muscles and terminates in the adductor pollicis. Lesions of ulnar nerve may occur on medial side of arm from superficial wounds, tourniquet or improper positioning on the operation table. Lesions at the heel of the hand compromise the interossei, 2 ulnar lumbricals, hypothenar musculature and volar sensory distribution. Deep branch of ulnar nerve may be affected by ganglia, fracture of carpal bones or haemorrhage. Muscles for grip strength are primarily supplied by the ulnar nerve and a complex clinical evaluation is required to determine the exact site of a lesion owing to the considerable anatomical variations.⁴ Variations in the branching pattern of ulnar nerve in the forearm is very rare and is important for diagnosing uncommon conditions. One such very rare variation is “all ulnar hand” where both motor and sensory supply of the hand is by the ulnar nerve without any communication with either median or radial nerve.⁵ Rarely, ulnar nerve may have Marinacci or reverse Martin-Gruber communication with the median nerve in the distal forearm.⁶

METHODS

This descriptive study was conducted in 40 embalmed upper limb specimens stored in the Department of Anatomy, Government Medical College, Kottayam. The upper limb specimens without any gross anomaly were included. Those specimens with crush injury or severe lacerations involving the hand were excluded from the study. The study period was 6 months from November 2018 to April 2019. The study was carried out by standard dissection method and dissection instruments. A transverse incision was put at the distal flexion crease of the wrist. The second incision was from the midpoint of the first incision to the center of the middle finger. The skin was reflected from the palm and palmar aspect of the medial three fingers. The ulnar nerve was identified and its distal course was traced.

At the wrist, ulnar nerve becomes superficial between the tendons of flexor carpi ulnaris (FCU) and flexor digitorum superficialis (FDS). Just proximal to the flexor retinaculum it pierces the deep fascia and enters the hand superficial to the flexor retinaculum. Then it passes deep to the palmaris brevis and divides into the terminal branches. The mode and level of terminal division of the main trunk of the ulnar nerve is noted. The branching pattern of superficial and deep branches of ulnar nerve was observed and its supply to the hypothenar muscles, lumbrical muscles, palmar and dorsal interossei were also noted. The presence or absence of the branch to flexor pollicis brevis was noted. Observations were recorded. Photographs were taken using digital camera. Data analysis was done and the results were compared with previous studies.

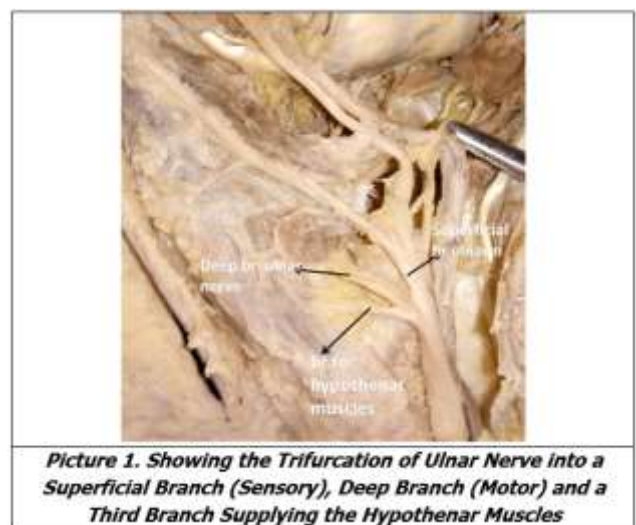
RESULTS

In the present study, 40 embalmed upper limb specimens were dissected to trace the distal course and terminal branching of the ulnar nerve trunk. The results obtained were as follows.

Mode of Termination of the Ulnar Nerve	Number of Specimens	Percentage (%)
Bifurcation of the nerve	29	72.5
Trifurcation of the nerve	11	27.5

Table 1. Mode of Termination of Ulnar Nerve

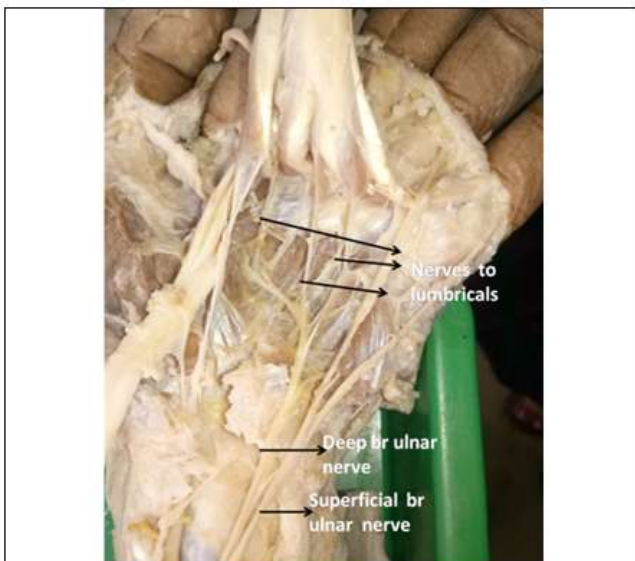
The terminal branching of the ulnar nerve was observed in 40 specimens. It was seen that in 29 specimens (72.5%), the termination of ulnar nerve showed a bifurcation pattern where the main trunk divided into a superficial sensory branch and deep motor branch. In 11 specimens (27.5%), the nerve was seen terminating in a trifurcation pattern. In 3 out of the 11 specimens, the nerve trifurcated into a superficial sensory branch, deep motor branch and a third branch which was seen supplying the hypothenar muscles (Picture 1). In the remaining 8 specimens the ulnar nerve trifurcated into 2 common digital sensory nerves and one motor branch.



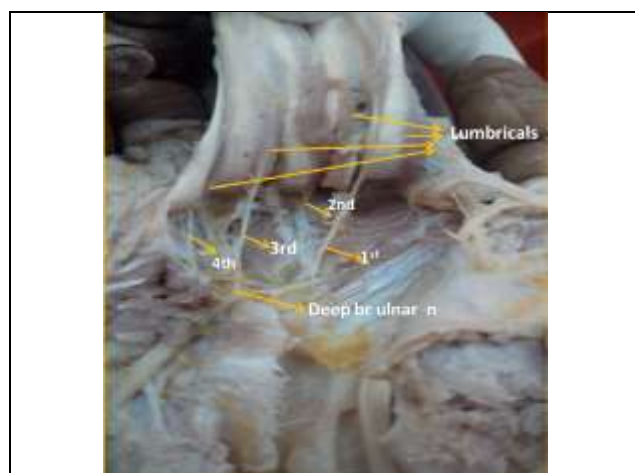
Level of Termination of Ulnar Nerve	No. of Specimens	Percentage (%)
Before entering the Guyon's Canal	5	12.5
Within the Guyon's Canal	35	87.5

Table 2. Level of Termination of Ulnar Nerve

In 35 specimens (87.5%), the ulnar nerve trunk was seen terminating within the Guyon's canal which is the most common level of termination. In 5 specimens (12.5%), the nerve terminated at higher level before entering the Guyon's canal (Picture 2).



Picture 2. Showing a High Level of Termination of Ulnar Nerve in The Wrist. The Nerve is Also Seen Supplying Second, Third and Fourth Lumbricals



Picture 3. Showing the Deep Branch of Ulnar Nerve Supplying all Four Lumbricals

No. of Lumbricals Supplied by the Deep Branch of Ulnar Nerve	No. of Upper Limb Specimens	Percentage (%)
Third and Fourth Lumbricals	37	92.5
Second, Third and Fourth Lumbricals	1	2.5
All Four Lumbricals	2	5

Table 3. Pattern of Nerve Supply to The Lumbricals

An interesting pattern was observed in the nerve supply to the lumbricals. In 37 specimens (92.5%), the deep branch

of ulnar nerve supplied the medial two lumbricals (third and fourth) while the lateral two lumbricals were supplied by the palmar digital branches of the median nerve. In 1 specimen (2.5%), second, third and fourth lumbricals were supplied by the deep branch of ulnar nerve which is an uncommon finding (Picture 2). In 2 specimens (5%), all the four lumbricals were supplied solely by the deep branch of ulnar nerve which is rarely seen (Picture 3).

Branching Pattern of Terminal Branches

In the present study, in 28/40 specimens superficial terminal branch divided into medial proper and common digital branches. In 12/40 specimens, the nerve divided into proper, common digital branches and a communicating nerve to digital branch of median nerve.

The nerve supply to the flexor pollicis brevis was also observed. The Flexor Pollicis brevis is said to have a dual supply from both median and ulnar nerves. In the present study, 32 specimens (80%) were seen to be supplied by the deep branch of ulnar nerve. In 8 specimens, the muscle was not supplied by the ulnar nerve. Deep branch of ulnar nerve was also seen to supply all palmar interossei, dorsal interossei, hypothenar muscles and adductor pollicis.

DISCUSSION

The ulnar nerve arises in the axilla from the medial cord of brachial plexus (C8 & T1). After coursing through the arm and forearm, the ulnar nerve enters the palm by passing superficial to the flexor retinaculum lying just lateral to the pisiform bone.⁷ Just distal to the pisiform bone, the ulnar nerve divides into its terminal superficial and deep branches. The superficial branch supplies Palmaris brevis and provides sensory innervations to the skin on the palmar surface of medial one and half fingers. The deep branch is purely motor and supplies all the intrinsic muscles of the hand except the tenor muscles and first two lumbricals. Anomalies of the sensory innervations of the hand are uncommon.

Bonnel F and Vila. R. M studied the ulnar nerve in 50 adult hands. The classic bifurcation was found in 39/50 cases (78%), 11 cases (22%) showed variations.⁸ In the present study the ulnar nerve bifurcated in 29 out of 40 specimens (72.5%) and trifurcated in 11/40 specimens (27.5%). In the study conducted by Lindsey et al in 31 specimens, 2 patterns of divisions of ulnar nerve was seen. In 25 cases (80%), the nerve bifurcated and in 6 cases (20%), the nerve trifurcated.⁹ According to Priyadarshini et al, in 29 out of 40 (72%) of the specimens the ulnar nerve bifurcated, in 10(25%) specimens, the ulnar nerve trifurcated in the Guyon's canal and in 1 (2.5%)specimen there was higher division of ulnar nerve and trifurcation.¹⁰ In 2010, Nitasu M et al, studied the variations of ulnar nerve in Guyon's canal using ultrasound and 3T MRI. In 21/30 hands (70%) hands, ulnar nerve bifurcated and in the rest it trifurcated. They also noted symmetrical branching of the ulnar nerve in both hands in 4 patients whereas asymmetrical branching in 11 patients.¹¹ Thus, the branching pattern of the ulnar nerve trunk in Guyon's canal varies and there is no exact level at which the nerve

terminates. In the present study it was seen that in 5 out of 40 specimens, the ulnar nerve divided before entering the Guyon's canal (high division). In the rest of specimens (35), the nerve divided in the canal.

In 1963, Kaplan¹² described a nerve branch that arose from the dorsal cutaneous branch of the ulnar nerve and finally merged with the superficial terminal branch of the ulnar nerve, this type of communication has been termed as "Kaplan anastomosis". Aberrant branching" of ulnar nerve means that a branch is given off the main trunk of the ulnar nerve in the distal forearm and this branch then re-joins the main nerve trunk or its sensory division within the Guyon's canal.¹³ The superficial terminal branch divided into 2 digital (1 common and 1 proper) branches in 67.5% of specimens and into 3 branches (2 digital and 1 communicating branch) in 32.5% specimens.¹⁰ In the present study, in 28/40 specimens superficial terminal branch divided into medial proper and common digital branches. In 12/40 specimens, the nerve divided into proper, common digital branches and a communicating nerve to digital branch of median nerve. The variant digital branches from the ulnar nerve were distributed to the ulnar half of the index, ulnar half of the middle and radial side of the ring finger. Absence of communicating branch between common digital branch of ulnar nerve and the 3rd digital branch of the median nerve has also been reported.¹⁴ In 2004, Bozkurt¹⁵ et al described the medial proper digital nerve to the little finger arising from the dorsal branch of ulnar nerve.

It has been mentioned that innervations to the second lumbrical was inconstant, sometimes derived from deep ulnar and sometimes having a double supply¹⁶. In the present study, in 37 specimens (92.5%), the deep branch of ulnar nerve supplied the medial two lumbricals (third and fourth) while the lateral two lumbricals were supplied by the palmar digital branches of the median nerve. In 1 specimen (2.5%), second, third and fourth lumbricals were supplied by the deep branch of ulnar nerve. In 2 specimens (5%), all the four lumbricals were supplied solely by the deep branch of ulnar nerve. In such cases, lumbricals will be spared in carpal tunnel syndrome. Deep branch of ulnar nerve also supplied all palmar interossei, dorsal interossei, hypothenar muscles and adductor pollicis. The Flexor Pollicis Brevis is said to have a dual supply from both recurrent branch of median nerve and deep branch of ulnar nerve. In the present study, 32 specimens (80%) were seen to be supplied by the deep branch of ulnar nerve. In 8 specimens, the muscle was not supplied by the ulnar nerve.

CONCLUSIONS

The present study showed many variations in the branching pattern of the nerve in the wrist and palm. The trifurcation of the nerve with the third branch supplying the hypothenar muscles was a significant finding. All the four lumbricals were seen supplied by the deep branch of ulnar nerve in 2 specimens which is very rare. So, a better understanding of such variations would help the clinicians to tackle uncommon presentations of ulnar nerve injury. A more elaborate study

on the branching pattern of the ulnar nerve would be more beneficial in the future.

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