NARRATIVE REVIEW

Clinico-anatomical insight into the unusual course, branching pattern and connections of ulnar nerve: A narrative review

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Abstract

Ulnar nerve originates from the lower trunk as a branch from anterior division, continuing as a branch from medial cord of the brachial plexus. It receives fibres from anterior rami of cervical nerve root 8 and the first thoracic nerve root. Ulnar nerve injury accounts for being the most common vessel of upper limb that results in hospitalisation. Knowing the variability in the anatomical pattern of ulnar nerve and its communication with various branches of nerves in the vicinity can have implications. The current narrative review comprised literature search on Google, Google Scholar and PubMed databases for articles published between 2015 and 2023 on the subject. The insight and understanding of the related ulnar nerve anatomy is likely to be of prodigious help to anatomists, surgeons, physicians and radiologists in preventing unexpected outcomes in the future.

Keywords: Anatomical, Unusual, Course, Branching, Connections, Ulnar nerve.

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Introduction

The ulnar nerve originates from the lower trunk as a branch from the anterior division, continuing as a branch from the medial cord of brachial plexus. It has fibres from anterior rami of cervical nerve root 8 (C8) and the first thoracic nerve root (T1). In the axillary region, the axillary artery lies lateral to it, while in the upper humerus level, the brachial artery lies lateral to it.[1,2] The ulnar nerve penetrates the medial intermuscular septum and then passes in a way that the medial epicondyle of humerus lies anterior to it.[2] The ulnar nerve leaves the posterior compartment of arm, and then enters the anterior compartment of the forearm.[3] The ulnar nerve enters the flexor compartment of the forearm by passing between the heads of flexor carpi ulnaris (FCU).[4] In the forearm, the ulnar nerve lies along the anterior surface of flexor digitorum profundus (FDP).[5] A few centimetres proximal to the wrist, the dorsal sensory branch arises that supplies the dorsal one-and-a-half region of hand and fingers on the medial side. The main trunk continues into the Guyon's canal and there it forms two end branches: a superficial branch (sensory) and a deep branch (motor).[4] Guyon's canal is present on the anterior-medial region of the hand having the ulnar nerve and artery as its contents.[6] The superficial branch supplies the skin region on the palmar side of hand in the medial one-and-a-half region along with supplying to the palmaris brevis. The muscular branch of ulnar nerve supplies interossei, 3rd and 4th lumbricals, and muscles of the hypothenar region.[5]

The ulnar nerve is the most common nerve of the upper limb that is involved in injuries, including supracondylar fractures of the arm.[5] Knowing the variability in the anatomical pattern of the ulnar nerve and its communication with various branches of nerves in the vicinity, it is imperative for surgeons to avoid surgical injuries.[7] Since there are variations along the course of ulnar nerve formation, branching and termination, caution is required while approaching the nerve to avoid any sort of surgical mishap.[6]

The insight and understanding of the anatomical alteration of the ulnar nerve and its related anatomy would be of prodigious help to anatomists, surgeons, physicians and radiologists. The current narrative review was planned to determine the anatomical variability in the formation, branching pattern and termination of the ulnar nerve.

Materials and Methods

The current narrative review comprised literature search on Google, Google Scholar and PubMed databases for studies published between 2015 and 2023 that mentioned variance in the normal branching pattern of the ulnar nerve along with its formation, communication and termination. Studies publish in the English language that mentioned clear methodology and results were included. Those with unclear methodology or results, and published in any language other than English were excluded.

Results and Discussion

Course of ulnar branches

A study conducted in India revealed that in 3% of the cadavers, the route of ulnar nerve in the arm is anterior to axillary artery (lower one-third) and brachial artery.[8]

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Among the females, the DUN was observed in the proximal and middle-third of the forearm in 6.8% and 13.7% of individuals, respectively, whereas among the males, there was absence in the proximal part of the forearm, and distally it was present in 21.9% of the studied cadavers.[9] Another cadaveric study mentioned variation in ulnar nerve course in the distal forearm as it was found to be alongside the median nerve before it enters the carpal tunnel.[10] The usual or common site of origin of the dorsal branch of ulnar nerve (DUN) is in the distal one-third of the forearm, but variations do exist in terms of overall distribution in the forearm (Table 1).[5-7,11,12] Patel et al. mentioned abnormal route mentioning looping of the ulnar nerve around FCU near the wrist.[5]

Branching pattern of ulnar nerve

A study mentioned that in 85% cadavers, ulnar nerve branches into superficial and deep branches. In 2% of the subjects, the nerve divided into two terminal branches: ulnar and radial trunks. The remaining ones were observed for 3 terminal branches. In 70% of individuals, a cutaneous branch could be observed arising from the superficial ulnar branch in the Guyon's canal.[6] Various studies have mentioned trifurcation of ulnar nerve.[5-7,11,12]

Anastomosis between ulnar nerve and other nerves

There are various abnormal communications between ulnar nerve and other nerves (Table2).[8-10,13-22] They are of various types, including Martin-Gruber (connection between ulnar and median nerves), Kaplan's (connection between superficial and dorsal branches of ulnar nerve), Berrettini (connection between common digital nerves of ulnar and median nerve) and Riche-Cannieu anastomosis (connection between DUN and recurrent branch of median nerve).[13-15,23-25] Some studies have even mentioned its origin from other cords of brachial plexus.[26] A research mentioned that in 6% of individuals, the ulnar nerve anastomosed with other branches. In 57% of cadavers, the communication was observed to be with the median nerve, while in 6% the anastomosis was among the branches of ulnar nerve.[6] A study mentioned that in 2% of limbs, the abnormal communication of ulnar nerve was with the radial nerve. The abnormal communicating branch was observed to lie before the course of radial nerve through the sulcus radialis. The branch was observed to be supplying medial head of triceps and joined the ulnar nerve just before its entry into the intermuscular septum. The anastomosing branch measured 5.1cm. In 2% of dissected specimens, the medial cutaneous nerve of the forearm had its connection with the ulnar nerve with a measurement of 3.6 cm. The branch entered the ulnar nerve way before it pierced the intermuscular septum.[13] An Iranian study revealed the presence of an abnormal branch measuring 13 cm with a diameter of 1.5 mm and the connection was observed at the mid-humerus level.[27] Another cadaveric study mentioned the length of communication branch to be 8cm, while the diameter was 13 mm.[28]

Martin-Gruber anastomosis

Martin-Gruber anastomosis is a type of communication that exists between the ulnar nerve and the anterior interosseous nerve or the median nerve in the forearm. Paulos et al. identified 45% cadavers having Martin-Gruber anastomosis. In 25% of the limbs the ulnar nerve had communication with the median nerve, while in 20% of the cases the abnormal communication was between the anterior interosseous nerve and the ulnar nerve.[23] A study

Table-1: Studies on abnormal branching pattern of the ulnar nerve.

Study Reference	Year	Place	Number of studied limbs	Number of limbs with variation/ percentage	Age (years)	Gender	Side of the limb with variability and gender with abnormality	Findings related to termination of ulnar nerve
Sirasanagandla[12]	2015	Manipal, India	1	1	70	Male	Right	Dorsal cutaneous branch gave three branches at the level of wrist after passing beneath the flexor carpi ulnaris
Sulaiman[7]	2016	Dundee, UK	144	19.6	Not mentioned	Not mentioned	Not mentioned	Trifurcation into a proper digital nerve, common digital nerve and a deep trunk -19.6%
Depukat[6]	2017	Krakow, Poland	50	13	Not mentioned	43 male 7 females	Not mentioned	Trifurcation into a common palmar digital nerve, medial palmar digital nerve and a deep branch – 13%
Patel[5]	2018	Seattle, USA	1	1	59	Not mentioned	Left	Absence of palmar cutaneous branch Trifurcation of ulnar nerve branches in the Guyon's canal. 1. Superficial branch 2. Deep branch 3. Additional branch
Syamly[11]	2021	Tamil Nadu, India	52	38.4% hands - ulnar nerve dividing at abnormal places	Not mentioned	Not mentioned	Not mentioned	28.8% hands - ulnar nerve dividing into superficial and deep branches in the mid region of flexor retinaculum 9.6% - division at the level of lower level of flexor retinaculum 8 specimen – trifurcation into muscular branch, superficial and deep branches

Table-2: Studies on the abnormal connections and atypical formation of the ulnar nerve.

Study Reference	Year	Place	Number of studied limbs	Number of limbs with variation/ percentage	Age (years)	Gender	Side of the limb with variability and gender with abnormality	Findings related to termination of ulnar nerve
Guru[13]	2015	Manipal, India	50	4	Not mentioned	Not mentioned	Right	8% incidence. 2 limbs – ulnar nerve had a contribution from the lateral cord. 1 limb – abnormal connection with radial nerve 1 limb – abnormal connection with medial cutaneous nerve of forearm
Lombardo[28]	2015	USA	1	1	24	Female	Left	An extra communication between radial and ulnar nerve at the proximal 1/3rd region of humerus.
Taheri[27]	2015	Birjand, Iran	1	1	75	Male	Right	Abnormal connection between the ulnar and the radial nerve at mid humerus level.
Al-Talalwah [9]	2015	Saudi Arabia	38	76	Not mentioned	Male: 22 Female: 16	Right: 38 Left: 38	Dorsal branch of ulnar nerve 78% distal 1/3 of forearm 17.2% middle 1/3 of forearm 3.9% proximal 1/3 of forearm
Torre [25]	2015	Brazil	1	1	Not mentioned	Male	Not mentioned	Kaplan's anastomosis (between superficial ramus and dorsal branch of ulnar nerve)
Duran [20]	2016	Pamplona, Spain	14	28	Not mentioned	Male: 13 Female: 1	Right (Male)	One out of 28 cases, there was an abnormal communication between the median nerve and ulnar nerve in the forearm.
Cavalheiro [29]	2016	Brazil	50	100	28-77 years	Male: 46 Female: 4	Right (13%) Left (14%)	Martin-Gruber anastomosis in 27% of forearms.
Hemmi [16]	2017	Okoyama, Japan	50 12 males 15 females	70% medial part of third finger 40% lateral part of third finger	Not mentioned	Not mentioned	Not mentioned	70% medial part of third finger 40% lateral part of third finger – supplied by deep branch of ulnar nerve Lateral side of 4th finger was supplied by DBUN (deep branch of ulnar nerve)– 98% 2% by SBRN (Superficial branch of radial nerve)
Arquez [33]	2017	Pamplona, Spain	17	34	47	Not mentioned	Right (Male)	There was one forearm (2.94%) with abnormal communication between radial nerve and ulnar nerve located in the proximal one third of posterior region of forearm.
Silva [30]	2017	Brazil	30	60	25-80	29 males 1 female	-	16.7% ulnar supply to triceps. Below are details 55% direct supply 33.3% through radial nerve 11.2% direct and communicating branch through radial nerve 10% musculocutaneous nerve communication
Chunder[14]	2017	Kolkata, India	15	30	Not mentioned	Not mentioned	One on right One on left	6.6% showed Martin-Gruber anastomosis
Emamhadi[34]	2018	Iran	32	64	18-75	Male: 42 Female: 22	Male: 1 (bilateral) Female: 2 (bilateral)	3 cases (9.37%) there was a communication observed between the ulnar nerve and the lateral cord of brachial plexus.
Develi[18]	2018	Ankara, Turkey	35	5	Not mentioned	Not mentioned	Right – 3 Left - 2	An abnormal branch to the medial head of triceps from the ulnar nerve. 14.7% In one individual bilateral abnormal branches to the medial head of triceps were observed
Veltre[10]	2018	Boston, USA	1	1	55	-	Unilateral	Ulnar nerve coursing over the transverse carpal ligament
Vargus[22]	2019	OH, USA	1	1	59	Male	Right	An abnormal nerve was observed arising from the superficial branch. Of ulnar nerve piercing palmar fascia and flexor retinaculum.
Nation[18]	2019	San Antonio, USA	1	1	94	Male	Right	Abnormal connection of dorsal cutaneous branch of ulnar nerve with the superficial branch of ulnar nerve (Kaplan's anastomosis) Superficial branch of ulnar nerve supplying flexor digiti minimi brevis
Tabassum[8]	2019	Darbhanga, India	15	30 15 right 15 left	Not mentioned	Not mentioned	Not mentioned	3% - ulnar nerve arose from the lateral cord of brachial plexus 3% originated below the tip of acromian process of scapula
Bini[17]	2020	Paris, France	15	21	Not mentioned	Male: 9 Female: 6	Not mentioned	In 2 out of 21 hands, there was a single branch from the deep branch of ulnar nerve supplying flexor pollicis brevis.
Wakode[15]	2020	Bhopal, India	1	1	25	Male	Right	Berrettini anastomois variant. Sensory supply of digits 2,3,4 and 5 by ulnar nerve.
Misiani[26]	2020	Nairobi	1	1	Not mentioned	Not mentioned	Right	Right ulnar nerve was formed by contribution from the lateral cord of brachial plexus
Chaudhary[19]	2022	Uttarakhand, India	30	2	Not mentioned	Not mentioned	Right	4% - abnormal formation with contributions from the lateral cord of brachial plexus

in Brazil mentioned that 9% of cadaveric forearms presented with Martin-Gruber anastomosis involving the anterior interosseous nerve.[29] Chunder et al. observed one such anastomosis on the left medial side of the median nerve that joined the lateral part of the ulnar nerve, the anastomosis was found in the middle-third of the forearm. Another communication was noted on the right limb where the median nerve was joined by the ulnar nerve at the elbow region.[14]

Riche-Cannieu anastomosis

Riche-Cannieu anastomosis is a type of anastomosis that exists between the median nerve and the ulnar nerve in the hand. Patel et al. in a case study mentioned such an existence in the left hand. The median nerve had abnormal connections with the superficial branch of ulnar nerve.[5] Caetano et al. reported this connection in all the samples.[24]

Distribution of motor branches of ulnar nerve

A study documented that majority of the muscular branches to the forearm muscles arose in the proximal one-third of the forearm. In 15% cases, the muscular branches arose at a lower level, but not beyond the level of the mid-forearm.[23] An electrophysiological study revealed that in the middle finger, 34% and 46% of contribution were dual from the superficial branch of radial nerve and the deep branch of ulnar nerve on the lateral and medial sides, respectively. In the 4th finger, dual innervation of the same nerves were 8% and 2% on the lateral and medial sides, respectively.[16] A study conducted in Ankara, Turkey has mentioned that in 14,7% of cases, the ulnar nerve gave abnormal muscular branches to triceps brachii muscle. The mean length of the variant branches supplying medial head of triceps was 20.2 mm, while the mean diameter was 1.16mm.[30]

Muscular branches to FCU

A study mentioned that in majority of participants, there were around 0-3 branches around the elbow that were observed to be supplying the FCU. Only one was observed to be without any branch around the elbow. Majority were having a single branch each both for the medial and lateral head of FCU. The mean distances below the medial epicondyle for the branches supplying the lateral and medial head of FCU were 19.5±9.5mm and 16.3±8.6mm, respectively.[31]

Muscular branches to FDP

A cadaveric study documented that in 90% of the cadavers, there was a single branch that supplied the FDP. In 20% of the upper limbs, there were two branches supplying the FDP. The average length of the branches to FDP was 3.3cm, while the average diameter was 0.2cm.[23]

Muscular branches to palmaris brevis

A study in Poland mentioned that in 52% of cadavers, the muscular branch of the palmaris brevis was from the superficial branch of ulnar nerve. In 34% of individuals, there was no branch to the palmaris brevis muscle. In 8% of cadavers, there were two branches from the superficial branch of ulnar nerve, while in 6% subjects, the branch to the palmaris brevis was from the main trunk.[6]

Muscular branches to hypothenar eminence

In most individuals, there is a single branch that supplies the muscles of hypothenar eminence. A study mentioned the absence of any muscular branches to hypothenar eminence in 78% subjects' hands. In only 2% of participants, the presence of double muscular branches to the hypothenar eminence was noted.[6] In a cadaveric study, on the left side, there was absence of deep branch of ulnar nerve supplying the hypothenar muscles.[5]

Muscular branches to adductor pollicis and first dorsal interossei

A research mentioned that there was inconsistency in the number of branches received by the two heads of adductor pollicis and first dorsal interossei (DOI). It was observed that in 100% of cadavers, the DOI received more than one branch, while it was 62% for the transverse head, and 95% for the oblique head of adductor pollicis.[17] A Brazilian study highlighted that in 17.5% of the observed hands, the oblique head of adductor pollicis received a dual nerve supply by the deep branch of ulnar nerve, while in 3.6% the transverse head of the muscle had a dual supply.[24]

Dimensional variations of ulnar nerve and surgical importance

Variability in the dorsal and the palmar branches of ulnar nerve are of vital importance as they are liable to injury in flap surgeries, carpal tunnel release techniques and other procedures.[10,12,15] The medical care and strategy related to therapeutic procedures vary according to the innervation pattern.[19,32] A study in Brazil mentioned the variability of abnormal branch to triceps muscle. The length varied from 1.1cm to 8.1 cm.[29] A study in Spain mentioned the total length of abnormal connection between median and ulnar nerve to be 6.5 cm. The communication was observed to be located 6.7cm lower than the medially placed epicondyle of humerus, while with reference to ulnar nerve, it was located 10.5 cm below the medial epicondyle.[20] Another study mentioned that the length of the communication between radial and ulnar nerves was 5.84cm, while the diameter of the nerve was 1.73 mm.[33] In a cadaveric study, the mean length of dorsal cutaneous branch of ulnar nerve from its origin to the styloid process of ulna was 4.92 cm. The nerve crosses the wrist region

distal to styloid process of ulna from supination to pronation position. This is vital knowledge as surgeons should ideally be approaching the nerve through supination or neutral position to avoid surgical injury.[21] Lombardo et al. documented that an extra communicating nerve between radial and ulnar nerve measured 8cm, while its diameter was 3 mm.[28] In spastic paralysis of the upper limb, mostly flexor carpi ulnaris and FDP are involved, leading to excessive flexion of wrist as well as ring and little fingers. This leads to compromised gripping of the hand. Additionally, the patients feel cosmetically compromised because of the posture. Since the diameter of motor branches of ulnar nerve varies between 0.05 cm and 3 cm, this can be taken into consideration while performing selective neurectomy. While performing selective neurectomy of FDP, surgeons should be vigilant enough to locate the branches between 2.8 cm to 8.7cm distal to the medial epicondyle of humerus.[23] A case report in the United States mentioned the invasion of transverse carpal ligament by an abnormal branch of ulnar nerve, encouraging the surgeons to be careful while making incision during carpal tunnel release.[22] Emamhadi et al. mentioned that 9.37% of the cadaveric limbs showed variability in the dimensions of ulnar nerve length from the mean 56.3±2.7cm.[34]

Conclusion

Globally, there exists variability in the course, branching pattern and connections of the ulnar nerve. In most of the studies, the anomalous formation was by the lateral cord of brachial plexus. The most common abnormal communications was observed with the median nerve followed by the radial nerve. Since the knowledge of ulnar nerve can hamper or modify the outcomes of surgical procedures performed in the hand, therefore, the stakeholders should keep up with latest knowledge about the anatomical abnormality.

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Author Contribution:

QJ: Design, data acquisition, interpretation, drafting, revision, final approval and agreement to be accountable for all aspects of work.