

Topography of the Formation of the Median Nerve and its Communication with the Musculocutaneous Nerve

Topografía de la Formación del Nervio Mediano y su Comunicación con el Nervio Musculocutáneo

Jongwan Kim¹; Soo-Jung Jung²; Yong Wook Jung¹; Katsuro Tachibana³ & Jae-Ho Lee⁴

KIM, J.; JUNG, S.-J.; JUNG, Y.W.; TACHIBAN, K. & LEE, J.-H. Topography of the formation of the median nerve and its communication with the musculocutaneous nerve. *Int. J. Morphol.*, 43(5):1478-1482, 2025.

SUMMARY: The median nerve (MN) is a peripheral nerve that arises from the brachial plexus. The formation of MN occurs through the fusion of two roots: the lateral root and the medial root, originating from the lateral and medial cord, respectively. MN anatomy including its formation, distribution, and communication was extensively diverse. The present study focused on topography of the MN and its anatomical variation in 112 upper limbs. The lateral and medial cords of the brachial plexus merged at the axillary level in 96.4 % of cadavers and at the brachial level in 3.6 % of cases to form the MN. The MN formation was found at a distance of $+ 8.71 \pm 20.06$ mm from the coracoid process, as the reference line. The location of MN formation was more distal in cadavers without COM than those with COM ($+13.44 \pm 23.77$ vs. $+2.89 \pm 12.76$, $P = 0.12$). Communication branch to the musculocutaneous nerve (COM) was detected in 44.6 % and its position was determined to be at $+ 43.84 \pm 35.90$ mm from the reference line. In some case, COM presence formed a small hole, and it was defined as ring formation. The location of COM was different according to the presence of the ring formation ($P < 0.001$). Understanding these anatomical variations is important for both anatomists and clinicians. Surgeons who conduct procedures related to neoplasms or trauma repair must possess knowledge of these variations.

KEY WORDS: Median nerve; Musculocutaneous nerve; Anatomical variation; Ring form.

INTRODUCTION

The median nerve (MN) is one of the terminal branches of the brachial plexus and is formed by two roots: the lateral root from the C5-C7 (lateral cord) and the medial root from the C8 and T1 (medial cord) (Johnson *et al.*, 2010). The musculocutaneous nerve (MCN) is another primary terminal branch of the brachial plexus. Typically, the MCN originates from the lateral cord of the brachial plexus and transports motor and sensory fibers from C5, C6, and C7 segments. In general, MN and MCN innervate the flexor muscles of the arm and forearm. In clinical-surgical practice, understanding the formation pattern of peripheral nerves, the topographical spaces in which they exist, and the relationships they form with vascular structures, as well as their distribution in the various muscle compartments, is critical (Soubeyrand *et al.*, 2020). Neural communication between nerves can cause clinical and electrodiagnostic results to be confusing (Emamhadi *et al.*, 2016). To avoid misdiagnosing peripheral nerve lesions, it is important to

understand the complex communication between the median nerve origin and nearby nerves. The anatomical variations in the median nerve have been discussed in terms of their clinical significance. These variations may lead to complications or unintended outcomes during regional anesthesia blocks, surgical procedures, axillary dissections in elective surgeries, trauma involving the trunks of the brachial plexus, nerve transpositions, and vascular surgeries (Porter *et al.*, 2022).

Several studies have shown variations of its formation and relationships with other anatomical structures. The most common variation in these nerves was the "communicating branch between the MN and MCN" (COM) (Beheiry, 2004; Guerri-Guttenberg & Ingolotti, 2009; Song *et al.*, 2024). The incidence of COM varied greatly, ranging from 5.0 % to 54.7 %, and this disparity could be attributed to differences in definition and precise dissection. However, anatomical

¹Department of Anatomy, Dongguk University School of Medicine, Gyeongju, Republic of Korea.

²Department of Anatomy, College of Korean Medicine, Daejeon University, Daejeon, Republic of Korea.

³Department of Anatomy, Faculty of Medicine, Fukuoka University, Fukuoka, Japan.

⁴Department of Anatomy, School of Medicine, Keimyung University, Daegu, Republic of Korea.

Jongwan Kim and Soo-Jung Jung, contributed equally.

location and topography of this variation have not been determined. Given the significance of these anatomical variations in the medial nerve in humans, we investigated and reported our findings in a variety of anatomical bodies. This study examined the topography of MN formation and COM in 112 upper limbs and anatomical association with other structures was considered. In addition, a newly identified variation, ring form, will be discussed, with consideration of its potential anatomical and clinical implications. This information has practical applications and can help with accurate diagnostic interpretation.

MATERIAL AND METHOD

In this study, 112 upper limbs (from 56 donated cadavers) were dissected. Each cadaver was placed in a supine position with arms abducted and palms facing up. The skin, superficial fascia, and adipose tissue were removed to expose the axillary artery. The pectoralis major and pectoralis minor muscles were dissected. After axillary vessel, teres major muscle, pectoralis major muscle and pectoralis minor muscle were dissected from each muscle and fascia, the brachial plexus was shown. The lateral and medial cords, MN and MCN was clearly identified. The location of MN formation was divided into two groups, axilla and arm, according to the arterial definition (the lower margin of the teres major muscle). When the connection between MN and MCN was found, it was defined as COM (communicating branch between the MN and MCN). In some case, COM branch formed a loop or small hole, and it was defined as “ring form”. Then, topography of median nerve formation and communicating branch was measure. The length from the coracoid process, as the reference line, and the location of the formation of the median nerve and communicating branch was measured. The coracoid process was an easily palpable

bony landmark on the surface of the skin and it was usually used as reference line for morphometric analysis of upper limb. For accurate morphometric analysis in this anatomical study, digital calipers (NA500-300S, Blue bird, Korea) were employed, and all measurements were recorded to the nearest millimeter. When the location was distal to the reference line, it was defied as plus, vice versa. The difference in topography of median nerve formation and communicating branch was compared according to the presence of COM and ring formation (Fig. 1).

All statistical analyses were conducted using SPSS (version 23.0, IBM SPSS®; Chicago, IL). The normality of the data distribution was assessed using the Shapiro–Wilk test. Based on the results, non-parametric tests, Mann–whitney test were used to analyze the relationship between the variations. P values <0.05 were considered to indicate statistical significance.

RESULTS

The lateral and medial cords of the brachial plexus joined at axillary level in 96.4 % (108/112) and brachial level in 3.6 % (4/112) to form MN. The location of MN formation was $+8.71 \pm 20.06$ mm (Min: -34.0 mm; Max: +92.0 mm) to the coracoid process (reference line). And COM was found in 44.6 % (50/112) and it was located at $+43.84 \pm 35.90$ mm (Min: 0 mm; Max +145.0 mm) from the reference line. The location of MN formation and communication branch was close and their tissues (Table I). The location of the median nerve and communication branch was not different according to the sex. The location of the median nerve was more proximal in cadavers with COM than cases without COM, though it did not get statistical significance ($+2.89 \pm 12.76$ vs. $+13.44 \pm 23.77$, $p = 0.12$).

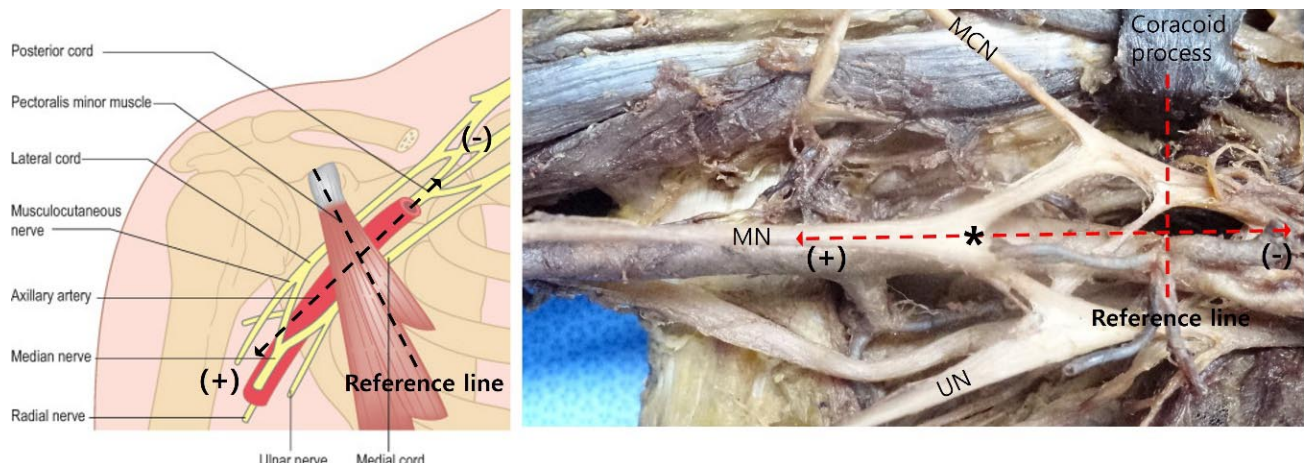


Fig. 1. The methods for measuring the topography of the median nerve (MN) and its associated structures. Asterisk, MN formation; MCN, musculocutaneous nerve; UN, ulnar nerve.

Table I. Topography of the median nerve and communication branch.

	Median nerve	P value	Communication branch	P value
Sex		0.73		0.54
Male	+9.36 ± 20.02		+40.42 ± 33.18	
Female	+7.85 ± 20.30		+48.57 ± 39.70	
Com		0.12		
(+) (n=50)	+2.89 ± 12.76		+43.84 ± 35.90	
(-) (n=62)	+13.44 ± 23.77		-	
Ring form		0.54		0.001
(+) (n=8)	+2.42 ± 16.50		+19.0 ± 12.16	
(-) (n=104)	+9.33 ± 20.38		+52.58 ± 37.46	

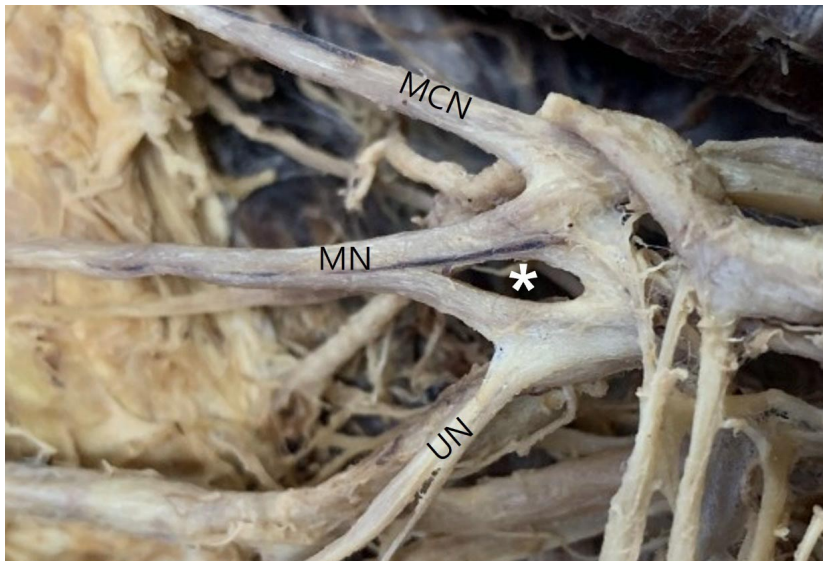


Fig. 2. The representative image of Ring-form of the median nerve (MN). Asterisk, Ring form; MCN, musculocutaneous nerve; UN, ulnar nerve.

When the COM was very close to the median nerve after it has formed, a loop or ring form tends to appear between the nerve bundles. We referred to this pattern as the “ring form” (Fig. 2) and found in 7.1 % (8/112) cadavers. The location of communication branch was statistically different according to the presence of the “ring form” (+19.0 ± 12.16 vs. +52.58 ± 37.46, $p = 0.001$).

DISCUSSION

The brachial plexus supplies either motor or sensory innervation to the upper limb. Normally, it is formed by the ventral rami of C5 to C8 and T1. The plexus arises in the neck and then crosses inferiorly over first rib. Afterwards, it enters the axillary cavity. At the infraclavicular level, the lateral fascicle of the brachial plexus usually bifurcates giving origin to the musculocutaneous nerve (MCN) and the lateral root of the median nerve (MN). MN is one of the terminal branches of the brachial plexus, which is formed by joining two roots, lateral and medial. The medial root (C8-T1) come from the medial cord and the lateral root (C5-C7) come from the lateral cord of the brachial plexus and embrace the 3rd part of the axillary artery and unite anterior or lateral to it. The nerve then passes medial to the brachial artery on the anterior compartment of the arm. MN as reported in literature, is associated with several variations which include abnormal communications with other nerves such as musculocutaneous

and ulnar nerves (Beheiry, 2004; Guerri-Guttenberg & Ingolotti, 2009). Moreover, double communication branch was found in recent study (Fumo *et al.*, 2024).

As usual, the median nerve was formed at axillary level in most of the cadavers, and distal formation of the median nerve was found in 3.6 %. The location of MN formation was +8.71 ± 20.06 mm distal to the coracoid process. This indicated that the median nerve is approximately formed beneath the coracoid process. A communication branch (COM) was found in 44.6 % and its presence did not affect the location of MN formation. However, the location of the median nerve tended to be more proximal in cadavers with COM though it did not reach statistical significance due to the large standard deviation. For a more accurate analysis, studies measuring relative length to the upper arm length are needed.

Interestingly, COM often branches immediately after the median nerve is formed. In this case, the epineurium of these nerves is connected, forming a loop or round hole (ring form). Although defining this form may be subjective, it can be defined as a case where the direction of the nerve bundles are not divided along the direction of progression, thus forming a hole. In our study, this form was found in 7.1 % and it did not have any association with the location of MN formation. Instead, this form was associated with the location of communication branch (COM), which was located at +43.84 ± 35.90 mm from the coracoid process. When the COM branched within the distance of one finger (20 mm), the incidence of a ring shape was significantly higher.

These variation may originated by incomplete cleavage of the nerve bundle during axonal growth in the embryologic development. Clinically, this variation was extremely important, because this spaces can become the passageways for other neurovascular structures. Similar

patten was found in both typical and atypical patterns. The middle meningeal artery ascends typically between the two roots of the auriculotemporal nerve to the foramen spinosum of the sphenoid bone. Songur *et al.* (2009) reported a fenestrated brachial vein perforated by the lateral root of median nerve. Zhou *et al.* (2024) found a fenestration of the facial nerve by the stylomastoid artery. Our group also reported a phrenic nerve encircling the transverse cervical artery (Lee *et al.*, 2021). These cases and our result demonstrated that this gap or ring formed by variations could give rise to additional variations through which neurovascular structures pass. The presence of these aberrations may contribute to varying clinical presentations, which could affect surgical approaches or contribute to pathologies like nerve entrapments or vascular compressions (Gümüşburun & Adigüzel, 2000; Uzun & Seelig Jr., 2001). Moreover, it also increased risk of iatrogenic injury or difficulties in during operative procedures and potential nerve dysfunctions resulting from abnormal mechanical stress on nerves encircling arteries or other structures.

One limitation of this study is subjective nature of defining the "ring form" of the nerve bundles, which could lead to variability in identifying and categorizing these structures. It is important to acknowledge that the identification of the 'ring form' may be subject to inter-observer variability. This study is the first to present this anatomical definition, and future studies should aim to establish standardized classification criteria and assess reliability to enhance the reproducibility of these findings. Furthermore, the study relied on cadaveric dissection, which may not accurately reflect the dynamic and functional aspects of these variations. Additionally, the large standard deviation in the location of the median nerve formation and the communication branch suggests that further investigation is needed to achieve more precise and statistically significant results. Future studies with more precise measurement techniques and imaging-based methods such as MRI and high-resolution ultrasound may provide further insights into the clinical relevance of these variations (Porter *et al.*, 2022).

CONCLUSIONS

This study highlights the significant anatomical variations in the formation of the median nerve and the presence of communication branches, which may contribute to variations in clinical presentations. The presence of a ring-shaped nerve formation associated with communication branches suggests potential clinical implications, such as the possibility of these spaces becoming passageways for other neurovascular structures. Although the incidence of such variations is relatively low, they underscore the importance of recognizing these anomalies, especially in surgical

planning and diagnosis of conditions like nerve entrapments or vascular compressions (Akhtar *et al.*, 2022; Ghosh *et al.*, 2022). Further research, including studies using imaging techniques and larger sample sizes, will be crucial to better understand the functional implications of these variations and improve surgical outcomes.

KIM, J.; JUNG, S.-J.; JUNG, Y.W.; TACHIBAN, K. & LEE, J.-H. Topografía de la formación del nervio mediano y su comunicación con el nervio musculocutáneo. *Int. J. Morphol.*, 43(5):1478-1482, 2025.

RESUMEN: El nervio mediano (NM) es un nervio periférico que surge del plexo braquial. Su formación se produce mediante la fusión de dos raíces: la raíz lateral y la raíz medial, que se originan en los fascículos lateral y medial, respectivamente. La anatomía del NM, incluyendo su formación, distribución y comunicación, fue muy diversa. El presente estudio se centró en la topografía del NM y su variación anatómica en 112 miembros superiores. Los fascículos lateral y medial del plexo braquial se fusionaron a nivel axilar en el 96,4 % de los cadáveres y a nivel braquial en el 3,6 % de los casos para formar el NM. La línea de referencia respecto a la formación del NM se encontró a una distancia de $+ 8,71 \pm 20,06$ mm del proceso coracoides. La ubicación de la formación del NM era más distal en los cadáveres sin COM que en aquellos con COM ($+ 13,44 \pm 23,77$ frente a $+ 2,89 \pm 12,76$, $P = 0,12$). La rama de comunicación al nervio musculocutáneo (COM) se detectó en el 44,6 % y su posición se determinó a $+ 43,84 \pm 35,90$ mm de la línea de referencia. En algunos casos, la presencia de COM formó un pequeño orificio, y se definió como formación de anillo. La ubicación de COM fue diferente según la presencia de la formación de anillo ($P < 0,001$). Comprender estas variaciones anatómicas es importante tanto para anatomistas como para médicos. Los cirujanos que realizan procedimientos relacionados con neoplasias o reparación de traumatismos deben conocer estas variaciones.

PALABRAS CLAVE: Nervio mediano; Nervio musculocutáneo; Variación anatómica; Forma anular.

REFERENCES

- Akhtar, M. J.; Kumar, S.; Chandan, C. B.; Kumar, B.; Sinha, R. R.; Akhtar, M. K. & Kumar, A. Variations in the formation of the median nerve and its clinical correlation. *Maedica (Bucur)*, 17(4):878-84, 2022.
- Beheiry, E. E. Anatomical variations of the median nerve distribution and communication in the arm. *Folia Morphol. (Warsz.)*, 63(3):313-8, 2004.
- Emamhadi, M.; Chabok, S. Y.; Samini, F.; Safae, M.; Behzadnia, H.; Firozabadi, F. A. & Reihanian, Z. Anatomical variations of brachial plexus in adult cadavers: a descriptive study. *Arch. Bone Jt. Surg.*, 4(4):253-8, 2016.
- Fumo, C.; Marzella, L.; Lazzerini, A.; De Francesco, F. & De Vitis, R. A double communication branch between musculocutaneous and median nerves: first case report, anatomical study, and comprehensive review of clinical implications. *Eur. Rev. Med. Pharmacol. Sci.*, 28(19):4376-82, 2024.
- Ghosh, B.; Dilkash, M. N. A.; Prasad, S. & Sinha, S. K. Anatomical variation of median nerve: cadaveric study in brachial plexus. *Anat. Cell Biol.*, 55(2):130-4, 2022.

- Guerri-Guttenberg, R. A. & Ingolotti, M. Classifying musculocutaneous nerve variations. *Clin. Anat.*, 22(6):671-83, 2009.
- Gümüşburun, E. & Adigüzel, E. A variation of the brachial plexus characterized by the absence of the musculocutaneous nerve: a case report. *Surg. Radiol. Anat.*, 22(1):63-5, 2000.
- Johnson, E. O.; Vekris, M.; Demesticha, T. & Soucacos, P. N. Neuroanatomy of the brachial plexus: normal and variant anatomy of its formation. *Surg. Radiol. Anat.*, 32(3):291-7, 2010.
- Lee, J. H.; Kim, H. T.; Choi, I. J.; Heo, Y. R. & Jung, Y. W. An unusual anatomical variant of the left phrenic nerve encircling the transverse cervical artery. *Folia Morphol. (Warsz.)*, 80(4):1027-31, 2021.
- Porter, S. B.; Garner, H. W.; Schoch, B. S.; Murray, P. M.; Robards, C. B. & Franco, M. J. Anomalous course of the brachial plexus identified during ultrasound-guided brachial plexus nerve block. *Turk. J. Anaesthesiol. Reanim.*, 50(4):312-4, 2022.
- Song, H. S.; Kim, M.; Yoon, S. P. & Kim, J. Unilateral variation of the median nerve in a human cadaver's arm. *Anat. Biol. Anthropol.*, 37(1):45-8, 2024.
- Songur, A.; Uygur, R.; Akçer, S. & Toktas, M. Fenestrated brachial vein perforated by the lateral root of median nerve: a case report. *Anatomy*, 3(1):65-8, 2009.
- Soubeyrand, M.; Melhem, R.; Protais, M.; Artuso, M. & Crézé, M. Anatomy of the median nerve and its clinical applications. *Hand Surg. Rehabil.*, 39(1):2-18, 2020.
- Uzun, A. & Seelig Jr., L. L. A variation in the formation of the median nerve: communicating branch between the musculocutaneous and median nerves in man. *Folia Morphol. (Warsz.)*, 60(2):99-101, 2001.
- Zhou, A. S.; DeVore, E. K.; Juliano, A. F. & Richmon, J. D. Fenestration of the facial nerve by the stylomastoid artery. *Head Neck*, 46(6):E67-E70, 2024.

Corresponding author:
Jae-Ho Lee
Department of Anatomy
School of Medicine
Keimyung University
Daegu
REPUBLIC OF KOREA

E-mail: anato82@dsmc.or.kr