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Bilateral Three-Rooted Median Nerve Formation With Musculocutaneous-Median Nerve Communications: A Cadaveric Case Report

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Abstract

The median nerve (MN) is typically formed by the union of lateral and medial roots arising from the corresponding cords of the brachial plexus. Variations in its formation and communications with the musculocutaneous nerve (MCN) are well documented, but their coexistence bilaterally remains anatomically noteworthy. During routine anatomical dissection of a 78-year-old male human cadaver, bilateral variations in MN formation and MCN-MN communications were identified. In both upper limbs, the MN was formed by two distinct lateral roots and one medial root. Additionally, a communicating branch between the MCN and MN was observed in each arm. The anatomical relationships of the roots and communicating branches to adjacent neural and vascular structures were documented photographically. Supernumerary roots and MCN-MN communications represent recognized variations of brachial plexus anatomy. Their bilateral coexistence in the present specimen highlights the complexity of peripheral nerve organization and the importance of distinguishing variations in nerve formation from interconnecting branches. Such configurations may complicate anatomical identification during surgical procedures, brachial plexus exploration, and regional anesthesia. This case report documents the bilateral coexistence of three-rooted MN formation and MCN-MN communications, adding to the anatomical literature on brachial plexus variations. Awareness of these configurations may enhance anatomical interpretation and help reduce the risk of inadvertent nerve injury during clinical interventions.

Categories: Orthopedics, Anatomy, Neurosurgery
Keywords: anatomical variation, brachial plexus, cadaveric study, median nerve, musculocutaneous nerve

Introduction

The median nerve (MN) is typically formed by the union of a lateral root from the lateral cord and a medial root from the medial cord of the brachial plexus. These roots usually fuse anterior or lateral to the second part of the axillary artery, giving rise to the MN before it enters the arm. Although this configuration is the standard anatomical pattern, variations involving accessory roots, atypical sites of union, and communications with neighboring nerves have been documented in cadaveric studies [1,2,3,4,5].

Among these variations, additional roots contributing to MN formation are of particular anatomical interest. Three-rooted and four-rooted configurations, as well as more complex patterns involving five roots, have been reported, with accessory roots originating from the lateral or medial cords, the musculocutaneous nerve (MCN), or other components of the brachial plexus [1,3,4,6,7]. These findings demonstrate considerable variability in the organization of the infraclavicular brachial plexus and highlight the importance of detailed anatomical examination when interpreting variant nerve configurations.

Communications between the MN and MCN are another well-recognized variation of the brachial plexus. Such connections differ in their origin, course, and relationship to the coracobrachialis muscle, and may be accompanied by additional variations in the formation and branching of the terminal nerves [2,5,8,9,10]. Venieratos and Anagnostopoulou [10] proposed a classification of MCN-MN communications based on the relationship of the communicating branch to the point where the MCN pierces the coracobrachialis muscle. Recognition of these connections is important because they may alter the expected distribution of nerve fibers and complicate the interpretation of clinical findings, electrodiagnostic studies, and surgical anatomy.

Although accessory roots and MCN-MN communications have each been described in the literature, their coexistence may produce a more complex brachial plexus arrangement than either variation alone. Such configurations are relevant to surgical procedures involving the axilla and arm, brachial plexus exploration, peripheral nerve repair, and regional anesthesia, where an incomplete understanding of variant neural anatomy may increase the risk of nerve injury or unexpected functional outcomes [1,4,5,8,10].

The present report describes bilateral variations in MN formation, marked by two lateral roots and one

medial root on each side, together with bilateral communications between the MN and MCN. According to the classification proposed by Venieratos and Anagnostopoulou [10], both communications were classified as Type II because they were located distal to the coracobrachialis muscle. This case report highlights the bilateral coexistence of multiple-rooted MN formation and interconnecting neural branches in both upper limbs, thereby contributing to the anatomical documentation of brachial plexus variability.

Case Presentation

During routine anatomical dissection of a 78-year-old male human cadaver, bilateral variations in the formation of the MN and in the communications between the MN and MCN were identified in the upper limbs. Examination of the right brachial plexus revealed an atypical configuration of the roots that contributed to the MN. In addition to the usual medial root, two distinct lateral roots were observed participating in the formation of the MN. These roots arose from the lateral aspect of the brachial plexus and coursed distally toward the MN, producing a variant pattern of MN formation. The roots were identified in the proximal arm, in relation to the axillary vessels and coracobrachialis muscle.

In addition, a communicating branch between the MCN and the MN was identified in the arm, in close proximity to the point where the MCN gave rise to the lateral cutaneous nerve of the forearm. The course of the communicating branch and its relationship to the adjacent nerves were documented during dissection (Figure *1*).

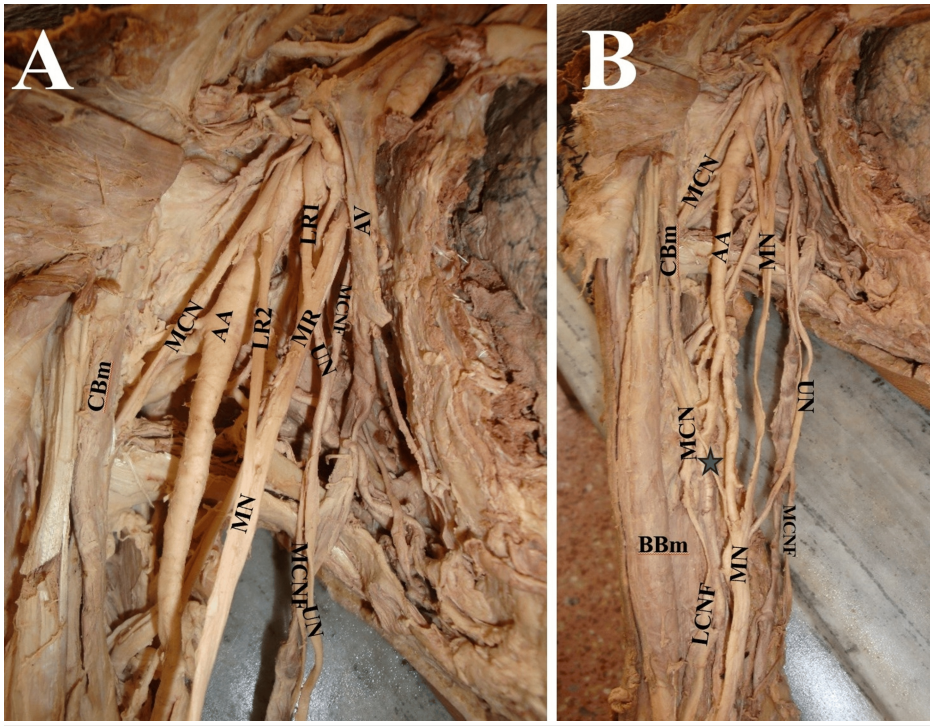


FIGURE 1: Double-root configuration of the median nerve and musculocutaneous–median nerve communication in the right upper limb

(A) Proximal view of the right brachial region demonstrating two lateral roots (LR1 and LR2) and a medial root (MR) contributing to the formation of the median nerve (MN), in relation to the axillary vessels and coracobrachialis muscle (CBm). (B) View of the right arm demonstrating the course of the median nerve (MN) and musculocutaneous nerve (MCN), with the communicating branch between the two nerves indicated by an asterisk

BBm: biceps brachii muscle; UN: ulnar nerve; AV: axillary vein; AA: axillary artery; LCNF: lateral cutaneous nerve of forearm; Cr: cranial; Cau: caudal; M: medial; L: lateral

Dissection of the left upper limb revealed a similar variation in MN formation, with two lateral roots and one medial root contributing to the MN. This configuration constituted a bilateral occurrence of multiple lateral roots of the MN together with an associated neural interconnection between the MN and the MCN.

The two distinct lateral roots and one medial root were observed on this side as well. The variant roots were identified in the proximal arm, in relation to the MCN, ulnar nerve, and coracobrachialis muscle. A communicating branch between the MCN and MN was also observed in the arm. Its relationship to the

brachial artery and adjacent neural structures was documented. These findings demonstrated a bilateral occurrence of multiple lateral roots contributing to MN formation and MCN-MN communication (Figure 2). The communicating branches originated from the MCN and joined the MN bilaterally, but their positions were asymmetrical: one was located in the middle third of the right arm and the other in the distal third of the left arm.

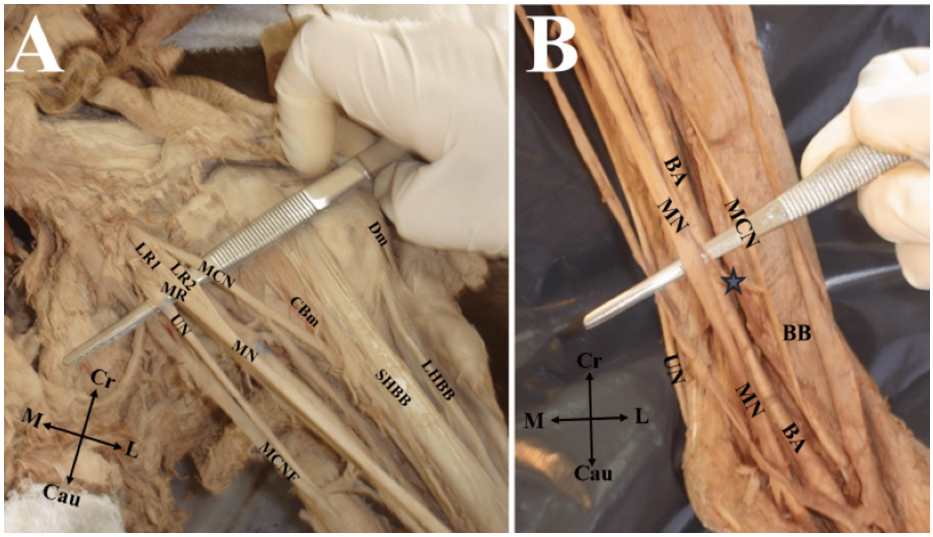


FIGURE 2: Variant formation of the median nerve and communication between the median and musculocutaneous nerves in the left upper limb

(A) Proximal view of the left brachial region demonstrating two lateral roots (LR1 and LR2) and one medial root (MR) contributing to the formation of the median nerve (MN), in relation to the musculocutaneous nerve (MCN), ulnar nerve (UN), coracobrachialis muscle (CBm), and the short and long heads of the biceps brachii muscle (SHBB and LHBB, respectively). (B) View of the arm demonstrating a communicating branch between the median nerve (MN) and musculocutaneous nerve (MCN), indicated by an asterisk, in relation to the brachial artery (BA), ulnar nerve (UN), and biceps brachii muscle (BB)

MCNF: medial cutaneous nerve of the forearm; Dm: deltoid muscle; Cr: cranial; Cau: caudal; M: medial; L: lateral

The principal findings were the bilateral presence of two lateral roots contributing to MN formation, accompanied by bilateral communications between the MCN and MN. The coexistence of these variations on both sides constitutes an unusual pattern of brachial plexus anatomy.

Discussion

The present case demonstrates a bilateral variation in MN formation, with two lateral roots and one medial root contributing on each side, accompanied by bilateral communications between the MN and MCN. Although accessory roots and communications between these nerves have been described individually, their bilateral coexistence is an anatomically noteworthy configuration. The findings emphasize the variability of the brachial plexus and the importance of documenting the relationships between its roots and terminal branches.

Variations in median nerve formation

The conventional formation of the MN involves the union of one lateral root from the lateral cord and one medial root from the medial cord of the brachial plexus. However, accessory roots may contribute to its formation, giving rise to three-rooted, four-rooted, or more complex configurations. Akhtar et al. [1] documented variations in MN formation and emphasized their clinical relevance, while Goyal et al. [2] described bilateral variations in the contributions to the MN. Natsis et al. [3] reported an unusual five-rooted configuration, and Passey et al. [4] documented several patterns of variation in MN formation. More recently, Yadav et al. [7] described asymmetrical variations involving triple- and quadruple-rooted configurations in a single cadaver.

The present case adds to these observations by demonstrating two lateral roots and one medial root contributing to the MN bilaterally. The bilateral occurrence is noteworthy because it shows a similar variant root configuration in both upper limbs of the same individual. Nevertheless, the presence of three roots should be distinguished from variations in the level of union, the origin of accessory roots, and their

relationship to the axillary artery. These features may differ considerably between specimens and should be documented separately when comparing anatomical reports.

The precise classification of the present configuration depends on confirming the origins and points of termination of both lateral roots. In particular, it is important to establish whether both roots arise independently from the lateral cord and whether they join the medial root separately or unite before forming the MN. This distinction would facilitate comparison with previously published descriptions and help identify the most appropriate anatomical terminology.

Communications between the median and musculocutaneous nerves

Communications between the MN and MCN are established anatomical variants that may involve connections at different levels of the arm. Venieratos and Anagnostopoulou [10] classified these communications according to their relationship to the point where the MCN pierces the coracobrachialis muscle. Subsequent reports have described a range of configurations, including communicating branches associated with accessory roots of the MN and more extensive alterations in the relationship between the two nerves [2,5,9].

Saeed and Rufai [5] documented variations involving the MN and MCN, including an accessory lateral root and a communicating branch. Piagkou et al. [9] also described coexisting neural variations involving the MCN and MN alongside variations of the coracobrachialis muscle. In addition, Antonopoulos et al. [11] reported fusion of the MN and MCN into a common neural trunk, illustrating the spectrum of anatomical relationships that may occur between these nerves.

According to the classification proposed by Venieratos and Anagnostopoulou [10], the bilateral MN-MCN communications observed in the present case were classified as Type II because both communicating branches were located distal to the coracobrachialis muscle. The coexistence of these bilateral communications with bilateral three-rooted MN formation is the principal anatomical feature of interest in this case.

Embryological considerations

Variations in brachial plexus anatomy are generally attributed to differences in the development and organization of the peripheral nerve pathways within the embryonic upper limb. The formation of the plexus involves the growth of axons from the ventral rami of spinal nerves, their interaction with the developing mesenchyme, and the establishment of connections with target tissues. Differences in axonal guidance, fascicular organization, and the persistence or regression of developing neural connections have been proposed as explanations for variations in nerve formation and communication [1,2,12,13].

The bilateral presence of additional roots and communicating branches in the present specimen may be consistent with variation in the establishment of these neural pathways. However, the precise embryological mechanism responsible for this configuration cannot be determined from adult cadaveric anatomy alone. Therefore, persistence of embryonic interconnections should be regarded as a possible explanation rather than a demonstrated mechanism.

Clinical significance

Knowledge of variations in MN formation and MCN-MN communication is relevant to procedures involving the axilla and arm, including brachial plexus exploration, peripheral nerve repair, surgical approaches to the proximal humerus, and regional anesthesia. Unexpected nerve connections may complicate anatomical identification and increase the risk of inadvertent injury during dissection or surgery. Variations in nerve branching may also affect the interpretation of neurological deficits and electrodiagnostic findings when the expected distribution of motor or sensory fibers is altered [1,4,5,10,14,15].

The present case highlights the importance of identifying the roots contributing to the MN and tracing any communicating branches between the MN and MCN before undertaking procedures in the region. Although the clinical consequences of the observed configuration cannot be established from a single cadaveric specimen, its documentation may assist clinicians and anatomists in recognizing comparable variations.

Limitations

This report describes a single cadaveric specimen and therefore cannot establish the prevalence of the observed configuration or its functional consequences. Furthermore, anatomical dissection alone cannot determine the direction of axonal transmission through the communicating branches or whether the variation produces clinically detectable motor or sensory effects. An additional limitation is the absence of morphometric data on the lengths and diameters of the medial and lateral roots, as well as the distance between the two lateral roots. Consequently, a quantitative comparison of these parameters with previously published studies was not possible. Further anatomical investigations involving larger samples, standardized morphometric measurements, and detailed documentation of root origins, union patterns, and

communicating branch trajectories are required to clarify the frequency, morphological characteristics, and classification of this combined variation.

Conclusions

This report describes a rare bilateral anatomical variation characterized by three-rooted median nerve formation and communications between the median and musculocutaneous nerves in both upper limbs. Its documentation contributes to the anatomical literature by highlighting the coexistence of these variations and their potential relevance to surgical procedures, regional anesthesia, and peripheral nerve assessment. This case report emphasizes the importance of recognizing individual variations in brachial plexus anatomy to improve anatomical interpretation and minimize the risk of iatrogenic nerve injury.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Christos Lyrtzis, Georgios Trikoilis, Maria Piagkou

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Supervision: Georgios Trikoilis, George Triantafyllou, Maria Piagkou, Yaren D. Kara

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Department of Anatomy, National and Kapodistrian University of Athens issued approval NA. This study involved the anatomical examination of a donated human cadaver during routine dissection at the Department of Anatomy, National and Kapodistrian University of Athens. Ethical requirements regarding the use of human cadaveric material were followed in accordance with the institutional policies and applicable regulations. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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