

Dual Anatomic Variations in the Median Nerve: Adding Layers of Complexity for Carpal Tunnel Release

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Abstract

Anatomical variations in the median nerve have been extensively documented since the inception of carpal tunnel surgery. We report a dual anatomic variation in the median nerve encountered during the carpal tunnel decompression. The bifid median nerve was associated with preligamentous thenar motor branch arising from the ventral aspect of the radial portion of the median nerve, remaining deep to antebrachial fascia and then piercing the transverse carpal ligament to reach the thenar muscles. Lanz described the various anomalies of the median nerve in the carpal tunnel and classified the bifid median nerve as group III. Various abnormalities associated with the bifid median nerve are further classified by Al-Qattan et al and classified the bifid median nerve associated with aberrant nerve branches as group VI.

Keywords

- ▶ bifid median nerve
- ▶ thenar motor branch
- ▶ carpal tunnel release
- ▶ anatomical variants
- ▶ median nerve

Introduction

Knowledge on the anatomical variations in the median nerve is essential, to avoid its iatrogenic injury during carpal tunnel release. In this article, we document a previously undescribed double variant of the median nerve in which the median nerve was found to be bifid associated with preligamentous thenar motor branch (TMB) arising from the ventral aspect of the radial portion of the median nerve, remaining deep to antebrachial fascia and then piercing the transverse carpal ligament to reach the thenar muscles. Bifid median nerve is commonly associated with persistent median artery or an anomalous muscle present between the two divisions of the nerve that were not encountered in this case. If the surgeon promptly recognizes the presence of

anatomic variants of the TMB, it may be possible to avoid iatrogenic injury during carpal tunnel release.

Case Report

A 36-year-old female homemaker with hypothyroidism presented with chief complaints of bilateral hand pain and numbness. She reported experiencing symptoms over the past few months, with a particular emphasis on the right hand. Her daily activities primarily involve homemaking duties, and she denied any recent traumatic events. Physical examination revealed decreased sensation in the distribution of the median nerve, a positive Tinel's sign over the right wrist, and symptom reproduction with Phalen's maneuver. Further assessment through nerve conduction studies was

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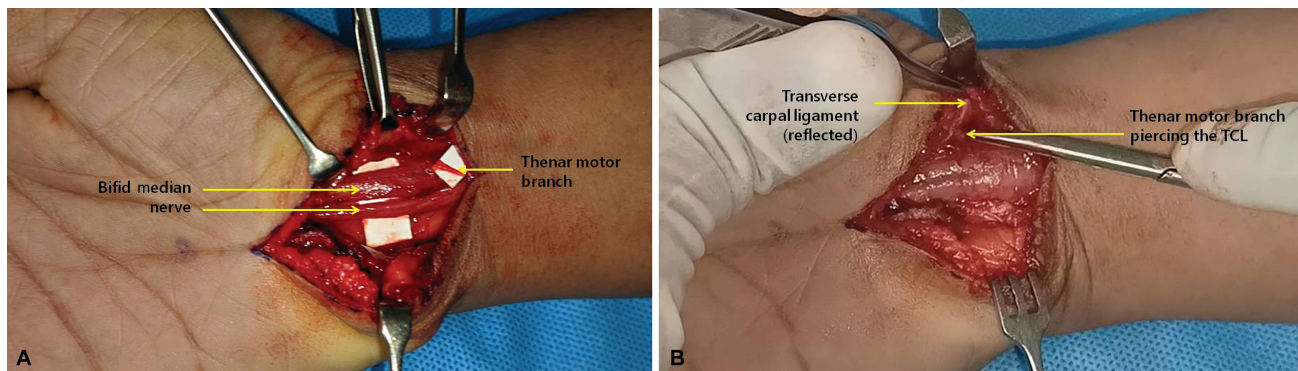


Fig. 1 (A) Intraoperative picture depicting the bifid median nerve associated with a preligamentous thenar motor branch arising from the ventral aspect of the radial division of the median nerve. (B) Thenar motor branch is seen piercing the transverse carpal ligament (TCL) to reach the thenar muscles.

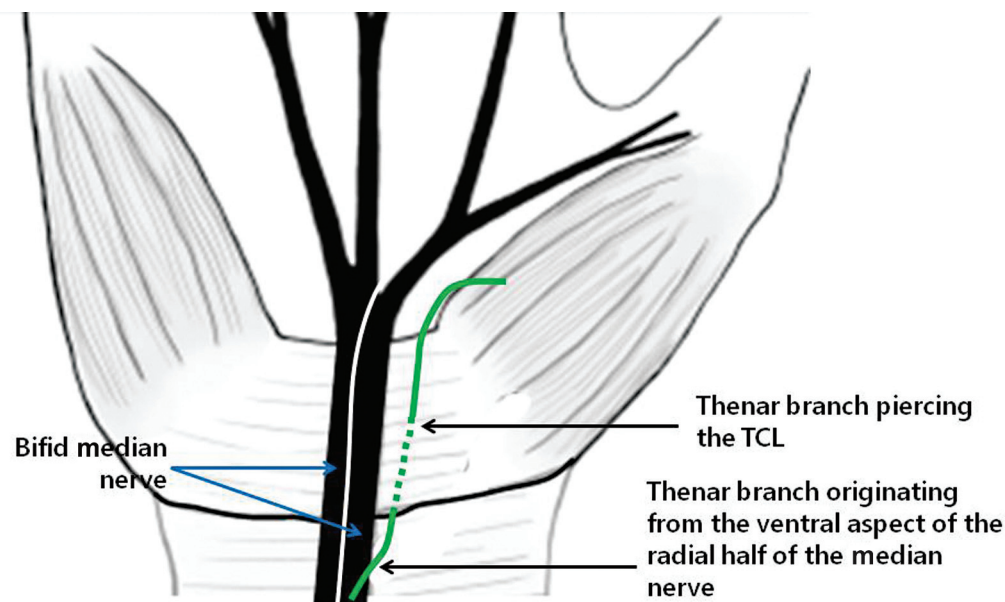


Fig. 2 Schematic representation of the variation. TCL, transverse carpal ligament.

performed revealing a moderate-to-severe degree of carpal tunnel syndrome. Given the severity of her symptoms, she opted for a right-sided open carpal tunnel release. The surgical procedure, conducted under supraclavicular block, revealed a dual anatomic variation in the median nerve. Notably, a bifid median nerve was encountered, the radial division larger than the ulnar division, associated with a preligamentous TMB arising from the ventral aspect of the radial division of the median nerve (►Figs. 1 and 2). This unique anatomical variation remained deep to the antebrachial fascia and pierced the transverse carpal ligament to reach the thenar muscles. The patient was provided with postoperative care instructions and was scheduled for regular follow-up to monitor her recovery and assess the resolution of her symptoms.

Discussion

The dual anatomic variation in the median nerve observed in our case offers a unique insight into the intricacies of carpal

tunnel anatomy and their implications for surgical procedures. While the reported incidence of bifid median nerves varies,¹⁻³ recent radiological studies^{4,5} hint at a potentially higher prevalence than traditionally acknowledged, underscoring the need to recognize such variations to avoid iatrogenic complications during carpal tunnel release. In our case, the bifid median nerve was associated with a distinctive preligamentous TMB, aligning with the classification system (discussed later) proposed by Al-Qattan et al.⁶ Group VI, as per Al-Qattan et al's classification, denotes the bifid median nerve associated with aberrant nerve branches, providing valuable insights into the potential complexities encountered during surgery.

Lanz's classification¹ was indeed one of the early and fundamental classifications regarding anatomical variations in the median nerve, and it provided a foundation for subsequent classifications, including those by Al-Qattan et al.⁶ The classification system proposed by Al-Qattan et al in 2009 provides a detailed framework for understanding the various anomalies associated with the bifid median

nerve, offering valuable insights for surgical planning. According to Al-Qattan et al's classification, the bifid median nerve is categorized into different groups based on the specific anomalies observed.

Group I—This group involves cases where the bifid median nerve is not associated with any other anomalies. Such occurrences are considered very rare and are typically asymptomatic. It is crucial to note that even in seemingly uncomplicated bifid median nerves, awareness is necessary during carpal tunnel release and other surgical interventions to avoid unexpected complications.⁷⁻¹⁰

Group II—Patients in this group present with a bifid median nerve accompanied by normal but persistent median vessels. Lanz noted that if persistent median vessels are encountered during surgical exploration of the distal forearm, a bifid median nerve should be suspected. This underlines the importance of recognizing the coexistence of anomalies during surgical procedures to optimize outcomes and prevent inadvertent injuries.

Group III—Al-Qattan et al's classification also addresses cases with pathology involving persistent median vessels. Patients in this group may present with arteriovenous malformations or aneurysms, leading to symptoms such as a pulsatile mass and carpal tunnel syndrome. The recognition of such pathologies is crucial, and preoperative angiograms may be necessary to guide surgical interventions effectively. Excision of persistent median vessels along with the malformation is typically curative, but the vascularity of the digits should be carefully assessed before excision to avoid complications.^{11,12}

Group IV—This group involves cases where there is a separate carpal tunnel for each division of the bifid median nerve. The clinical relevance of this classification is evident in scenarios of acute trauma and carpal tunnel syndrome, where both tunnels should be addressed during surgical interventions. The potential for endoscopic carpal tunnel release to miss one of the two compartments further emphasizes the importance of recognizing these variations for effective surgical planning.^{3,13,14}

Group V—Patients in this group exhibit an anomalous muscle found between the two divisions of the bifid median nerve. The presence of anomalous muscles, including an accessory first lumbrical, an accessory palmaris longus, a prolonged flexor superficialis muscle belly, or a palmaris profundus, has been reported. Recognition of such anomalies is essential during carpal tunnel release to prevent persistent sensory symptoms.^{15,16}

Group VI—This group is particularly relevant to our case, as it involves the bifid median nerve associated with aberrant nerve branches. Such branches may include two or three thenar branches, an aberrant sensory branch to the third web space, a transligamentous or abnormal ulnar origin of the motor branch, and an unusual terminal arborization of the branches of the median nerve. Careful dissection is required during surgical explorations in these patients to avoid injury to the aberrant branches. This classification highlights the potential complexities that may be encountered during surgery and reinforces the need for detailed anatomical understanding.^{17,18}

Unlike some cases in the literature,^{1,6,19} our patient did not exhibit a persistent median artery or any anomalous muscle between the divisions of the bifid median nerve. This absence of additional anomalies, such as anomalous muscles, adds a layer of clarity to our case and highlights the diversity within the spectrum of bifid median nerve variations. Our case aligns more accurately with Al-Qattan et al's classification system, group VI, which involves the bifid median nerve associated with aberrant nerve branches. The absence of an anomalous muscle and other specific anomalies in our case underscores the need for precise categorization based on the observed variations. This highlights the intricate nature of anatomical variations within the spectrum of bifid median nerves and emphasizes the significance of understanding the nuances of each classification to optimize surgical planning and outcomes.

The preligamentous variety refers to a unique anatomical configuration where the TMB arises from the radial or ulnar side of the median nerve in the distal forearm. This is in contrast to the more typical course where the TMB arises within the carpal tunnel. In the specific case described by Al-Qattan et al,²⁰ the preligamentous TMB variant was arising from the ulnar side of the median nerve and maintaining its course deep to both the antebrachial fascia and the transverse carpal ligament until it reaches the thenar muscles. But in our case, preligamentous TMB was arising from the ventral aspect of the radial division of the median nerve, remaining deep to antebrachial fascia and then piercing the transverse carpal ligament to reach the thenar muscles. This unique course puts the TMB at significant risk of injury during both open and endoscopic carpal tunnel release procedures. From a surgical standpoint, awareness of the preligamentous variety is crucial. Surgeons need to exercise additional caution during carpal tunnel release procedures to identify and preserve the preligamentous TMB, thereby minimizing the risk of iatrogenic injury. Preoperative imaging, such as ultrasound or magnetic resonance imaging, may aid in identifying these variations and guide surgical planning. The preligamentous variety of the bifid median nerve, as described in our case, adds a layer of complexity to surgical considerations. Its unique course increases the risk of injury during carpal tunnel release, underscoring the importance of precise anatomical knowledge and a tailored surgical approach.

In our case, the documented larger radial division of the bifid median nerve diverges from the typical observation noted by Lanz,¹ where the two parts are usually equal in size. The asymmetry in size introduces nuances that require careful attention to ensure a thorough release of both divisions, minimizing the risk of overlooking any part of the bifid median nerve. Surgeons must be mindful of the functional implications of this size difference, especially concerning sensory and motor innervation to the fingers.

Conclusion

In conclusion, our case contributes to the evolving comprehension of bifid median nerve variations. Al-Qattan et al's classification system, particularly group VI, provides a specific and relevant framework for understanding and

addressing associated anomalies during surgery. Surgeons must remain vigilant, considering the potential variations in bifid median nerve anatomy, to ensure optimal outcomes and prevent iatrogenic complications. Further research is warranted to refine classification systems and explore the utility of preoperative imaging techniques for accurate identification and surgical planning specific to cases like ours.

Ethical Approval

Institutional research ethical committee approval was obtained for the study.

Informed Consent Declaration

Written informed consent was obtained from all subjects before the study. There is no information (names, initials, hospital identification numbers, or photographs) in the submitted manuscript that can be used to identify patients.

Availability of Data and Materials

Not applicable.

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Conflict of Interests

None declared.

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