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Research Article

Anatomical Variant of Ulnar Nerve Trifurcation in Guyon's Canal: Clinical Implications and Case Report

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ABSRACT
Introduction: The ulnar nerve (UN), a continuation of the medial cord of the brachial plexus (C8, T1), traverses the medial aspect of the upper limb and enters the hand through Guyon's canal—a fibro-osseous tunnel located between the pisiform and the hook of the hamate bones. Within this canal, the UN typically bifurcates into a superficial sensory branch and a deep motor branch. However, anatomical variations, such as trifurcation, though rare, have been documented. Understanding these variations is crucial for clinicians, as they have significant implications in the diagnosis of entrapment neuropathies and during surgical interventions in the wrist and hand regions.
Case Report: A cadaveric dissection was performed at the Department of Anatomy, King George's Medical University, Lucknow following Cunningham's Manual. A longitudinal incision was made along the medial forearm to the little finger. The ulnar nerve (UN) was exposed by retracting the flexor carpi ulnaris and traced through Guyon's canal. An unusual trifurcation of the UN was observed in the right hand, while the left showed the typical bifurcation into superficial and deep branches. Division levels were noted with respect to the flexor retinaculum, medially between the pisiform and hook of hamate.
Conclusion: Trifurcation of the ulnar nerve in the ulnar tunnel highlights the need for awareness of anatomical variations, which, though often asymptomatic, are clinically significant in entrapment neuropathies and surgery, aiding in diagnosis, prevention of injury, and surgical planning.

INTRODUCTION

The ulnar nerve originates from the medial cord of the brachial plexus, primarily comprising fibers from the C8 and T1 nerve roots. Occasionally, it may receive contributions from the C7 root as well. In the Arm:The nerve descends along the medial aspect of the upper arm, initially positioned medial to the axillary artery and subsequently the brachial artery. At approximately the midpoint of the arm, it pierces the medial intermuscular septum to enter the posterior compartment, coursing posterior to the medial epicondyle of the humerus within the ulnar groove—a region commonly referred to as the "funny bone" At the Elbow: The ulnar nerve traverses the cubital tunnel, a fibro-osseous canal formed by the medial epicondyle of the humerus and the olecranon process of the ulna. The roof of this tunnel is constituted by Osborne's ligament, an extension of the deep forearm fascia . In the Forearm: Upon exiting the cubital tunnel, the nerve enters the anterior compartment of the forearm by passing between the two heads (humeral and ulnar) of the flexor carpi ulnaris muscle. It then courses distally between the flexor carpi ulnaris and the flexor digitorum profundus muscles, providing motor innervation to both. At the Wrist and Hand: Near the wrist, the ulnar nerve gives off a dorsal cutaneous branch that supplies sensation to the dorsal aspect of the medial one and a half fingers. The main trunk of the nerve continues into the hand by passing superficial to the flexor retinaculum and entering Guyon's canal—a fibro-osseous tunnel situated between the pisiform and the hook of the hamate bones. Within Guyon's canal, the ulnar nerve typically bifurcates into a superficial sensory branch and a deep motor branch, which innervate various intrinsic muscles of the hand and provide sensory innervation to the medial one and a half fingers on the palmar side [1]. Anatomical Course and Muscular Innervation of the Ulnar Nerve The ulnar nerve, originating from the medial cord of the brachial plexus (C8–T1), descends along the medial aspect of the upper arm. At the elbow, it passes posterior to the medial epicondyle ofthe humerus through the cubital tunnel. Entering the forearm, the nerve traverses between the two heads of the flexor carpi ulnaris muscle. It then courses distally, situated between the flexor carpi ulnaris and the flexor digitorum profundus muscles. In the forearm, the ulnar

nerve provides motor innervation to the flexor carpi ulnaris and the medial (ulnar) half of the flexor digitorum profundus, which controls the fourth and fifth digits. Approaching the wrist, the ulnar nerve travels superficial to the flexor retinaculum and enters the hand through Guyon's canal—a fibro-osseous tunnel bordered by the pisiform and the hook of the hamate bones. Within this canal, the nerve bifurcates into a superficial sensory branch and a deep motor branch, facilitating sensory and motor functions in the hand [2].

Guyon's canal, also known as the ulnar tunnel, is a fibro-osseous passage approximately 4–4.5 cm in length, situated on the anteromedial aspect of the wrist. It extends from the proximal edge of the pisiform bone to the distal aspect of the hook of the hamate bone. Anatomical Boundaries: Roof (superficial boundary): Formed by the palmar carpal ligament, palmaris brevis muscle, and hypothenar connective tissue. Floor (deep boundary): Composed of the flexor retinaculum (transverse carpal ligament), pisohamate ligament, and hypothenar muscles .Medial (ulnar) wall: Consists of the pisiform bone, flexor carpi ulnaris tendon, and abductor digiti minimi muscle.Lateral (radial)wall: Formed by the hook of the hamate bone. Contents:Within Guyon's canal, the ulnar nerve and ulnar artery pass into the hand. The ulnar nerve typically bifurcates within the canal into a superficial sensory branch and a deep motor branch .Understanding the detailed anatomy of Guyon's canal is crucial, especially in clinical contexts such as diagnosing and managing ulnar nerve compression syndromes.[3]. Within Guyon's canal, just distal to the pisiform bone, the ulnar nerve typically bifurcates into: Superficial sensory branch: Provides sensation to the little finger and the ulnar half of the ring finger. Deep motor branch: Innervates the hypothenar muscles and continues into the deep palmar space to supply the interossei and the third and fourth lumbricals. Although variations in this bifurcation are rare, they can have significant clinical implications during wrist surgeries and in the diagnosis of ulnarneuropathies [4].

CASE REPORT

A detailed cadaveric dissection was carried out in the Department of Anatomy at KingGrorge's Medical University,Lucknow, adhering to the procedures outlined in Cunningham's Practical Manual. A longitudinal incision was made along the medial aspect of the forearm and hand, extending from the medial epicondyle to the little finger. The skin and subcutaneous tissue were carefully reflected to expose the underlying fascia. The flexor carpi ulnaris muscle was identified and retracted, revealing the ulnar nerve lying deep to it. The dissection continued to Guyon's canal, where the overlying tissues were removed to visualize the course of the ulnar nerve as it passed through.An unusual anatomical variation was observed in the right hand—a trifurcation of the ulnar nerve within Guyon's canal (Fig. 1). The nerve was seen dividing into superficial and deep branches along the middle part of the flexor retinaculum, specifically between the pisiform bone and the hook of the hamate. In contrast, the left hand displayed the normal bifurcation pattern (Fig. 2), with the ulnar nerve dividing into its two terminal branches: the superficial sensory branch and the deep motor branch, at the distal part of the flexor retinaculum.All findings were captured using a DSLR camera and compared to the standard anatomical presentation.

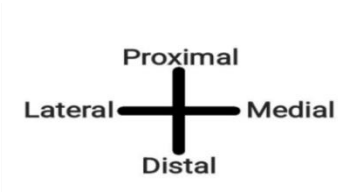

Figure 1. Picture of the right-hand showing trifurcation pattern of the ulnar nerve – 1.Muscular branch, 2.Deep branch, 3.Superficial branch.

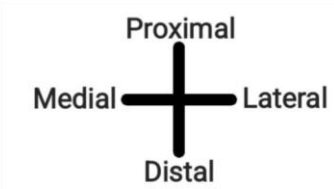

Figure 2. Picture of the left-hand showing bifurcation pattern of the ulnar nerve Branches Communicating to median nerve 2- Common palmar digital branch.

DISCUSSION

Variations in the branching pattern of the ulnar nerve have been seen in cadaveric dissections [5,6] and during clinical practice [7,8]. The branching pattern of ulnar nerve in the Guyon's canal is bifurcation into two branches as observed by Depukat et al. [5]. It showed that the ulnar nerve most commonly branched into two branches; a superficial sensory branch and a deep motor branch in 85% of cases.

The trifurcation of the ulnar nerve seen in the current study was the same as Ali T.F et al. Ali TF et al observed an anatomical variation of the ulnar nerve. There was a trifurcation of the ulnar nerve in the ulnar tunnel proximal to the pisiform bone [9].

Murata et al [10] and Verhiel et al [11] observed trifurcation of ulnar nerve and incidence was 9% and 22% respectively. The ulnar nerve follows the trifurcated type with one deep branch and two superficial branches inside the ulnar tunnel. In this case, the ulnar nerve represents the low trifurcated pattern, as it is divided inside the ulnar tunnel and the dorsal sensory branch, which originates normally proximal to the wrist, turns back to enter the dorso-ulnar side of the distal forearm to supply sensation to the skin of the dorsum of the hand as well as the dorsal aspects of the little and ring fingers. A high trifurcation pattern was reported in a case report by Al-Qattan et al. [7]. The ulnar nerve is found trifurcated in the middle of the forearm into a dorsal sensory nerve, an intermediate motor, and a radial volar sensory branch.

The clinical importance of the ulnar nerve pathway and its variations in the wrist mostly related to its entrapment in the Guyon's canal. There are three zones that were described to help localization of the lesion of the ulnar nerve in the wrist [12], Ulnar nerve lesions at the wrist are classified into three zones based on anatomical location and functional impact:Zone 1: Proximal to or within the ulnar tunnel before bifurcation; injuries here affect both motor and sensory branches, Zone 2: Distal to Zone 1; involves only the motor branch, causing paralysis of intrinsic and/or hypothenar muscles, while sensation remains intact, Zone 3: Radial to Zone 2; involves only the superficial sensory branch, leading to sensory loss in digit 5, the medial half of digit 4, and the hypothenar eminence.Due to anatomical variations, such as ulnar nerve trifurcation observed in some cases, patients may present with atypical zone involvement. Classic anatomical textbooks often lack detailed descriptions of these variations. Further research is needed to enhance anatomical understanding and improve clinical outcomes.

CONCLUSION

Understanding variations of the ulnar nerve (UN) is crucial for surgeons, as it aids in the diagnosis and interpretation of symptoms that may not be explained by typical anatomical patterns. Recognizing these anatomical variations is essential for preserving variant nerve branches during hand surgeries such as carpal tunnel release, ulnar tunnel exploration, palmar fasciectomy, and other procedures.

Since nerve variations can result in a range of clinical symptoms, detailed anatomical knowledge of the ulnar nerve and its branches is vital. This understanding supports accurate diagnosis and effective treatment of conditions such as ulnar nerve compression in Guyon's canal. Such anatomical insights are especially valuable in surgical and orthopaedic practices, where precision is critical to avoiding iatrogenic injury and ensuring optimal patient outcomes.

CONFLICT OF INTEREST

None.

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