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Dynamic Shifts of the Deep Ulnar Nerve Branch with Wrist Movement

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KEYWORDS

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ABSTRACT:

This study on cadavers looks at how the deep branch of the ulnar nerve moves in the distal ulnar compartment near the hook of the hamate. It also investigates whether there is a risk of nerve compressing during different wrist movements. Researchers dissected 30 hands preserved in formalin (15 right and 15 left) from 22 male and 8 female cadavers. When the wrist was in a neutral position, they found the deep branch of the ulnar nerve 2.9 mm from the ulnar side of the hook of the hamate. This distance decreased to 2.3 mm when the wrist flexed and 1.9 mm when it ulnarly deviated. On the flip side when the wrist extended or radially deviated, the nerve shifted making the distance a slang bigger. These shifts may increase the likelihood of ulnar nerve compression in individuals who frequently flex their wrists or move them toward the ulnar side. Knowing about these anatomical relationships is key for doctors and surgeons to improve their surgical techniques to lower the risk of hurting the nerve and better treat ulnar tunnel syndrome.

1. Introduction

The ulnar nerve starts from the medial cord of the brachial plexus (C8 and T1) and follows a unique path through the body. It first runs along the inner side of the axillary and brachial arteries before it turns to the back and enters the posterior arm compartment at the middle of the humerus. As it moves down into the forearm, the nerve pops up between the two heads of the flexor carpi ulnaris muscle and travels deep along the flexor digitorum profundus muscle until it gets to the palm [1-4].

Near the pisiform bone, the ulnar nerve splits into two main branches: a superficial sensory branch and a deep motor branch. The superficial branch gives feeling to the little finger, the inner part of the ring finger, and the ulnar side of the hypothenar eminence. The deep branch goes through the hypothenar tunnel giving movement to the hypothenar muscles before it continues between the top and bottom layers of the opponens digiti minimi muscle. It then bends around the hook of the hamate to give movement to the third and fourth lumbricals, the palmar and dorsal interossei, the adductor pollicis, the ulnar head of the flexor pollicis brevis, and nearby carpal joints [5-8].

The deep ulnar nerve branch gives off motor branches. These branches make the flexor digiti minimi, abductor digiti minimi, and opponens digiti minimi muscles work. The branch to the abductor digiti minimi can start above or below the pisohamate arch. This branch runs on top of the arch. So, a lot of pressure at the hypothenar tunnel might weaken the interosseous muscles but not affect the abductor digiti minimi. The part of the ulnar nerve that feels things and the top branch of the ulnar artery go through the upper part of the hypothenar tunnel. Denman and Schmidt described the lower part also called the distal hiatus of Guyon's canal. It's a fibrous arch that goes between the flexor digiti minimi and abductor digiti minimi muscles joining the pisiform bone and the hamate. The deep ulnar nerve and the deep branch of the ulnar artery pass through this space [9,10].

Multiple research projects have investigated how structures in Guyon's canal shift when the wrist moves. Kwon and his team studied these changes. They found that when the wrist is in a neutral position, the ulnar nerve sits 2 mm to the ulnar side of the hamate's hook. As the wrist moves from radial flexion to ulnar flexion, where they found a progressive radial migration of the ulnar neurovascular bundle. The ulnar artery, which is, on average, 0.1 mm ulnar to the hook of the hamate in neutral position, is displaced radially up to 5.7 mm with ulnar flexion, while radial flexion displaces the artery ulnarly [11].

Similarly, Hong et al. conducted a cadaveric studyto determine the correlation of neurovascular structures with the transverse carpal ligament in the context of endoscopic carpal tunnel release. They obtained positive significant dynamic displacement of Guyon's canal contents with movement of the wrist. In neutral position of the wrist, the average distances from the lateral border of the hook of the hamate to the center of the ulnar nerve and ulnar artery were 7.5 mm and 4.2 mm, respectively. They were increased to 8.1 mm and 5.0 mm by radial flexion but decreased to 4.2 mm and 0.8 mm by ulnar flexion [12].

Despite such research, literature does not contain concre te information regarding the impact of more than one position of the wrist on the anatomical course of the ulnarnerve. Such studies have focused primarily on pred efined positions and have not followed systematic evaluation of variation across different positions.

2. Objectives

The present work aims to determine the effect of four various positions of the wrist on the deep branch of the ulnar nerve within the ulnar tunnel, more specifically in relation to the hook of the hamate.

3. Methods

Study Design and Specimens

This descriptive cross-sectional study was conducted on 30 formalin-fixed cadaveric hands (15 right-handed and 15 left-handed). The cadavers, which were procured from the Department of Anatomy at Jazan University, consisted of 22 males and 8 females, with an estimated age range of 32 to 60 years (mean age: 55.5 years). The specimens having deformities, fractures, or signs of previous injury were excluded. Cadavers having restricted joint mobility were also excluded from the study.

Dissection Procedure

All specimens were positioned supine, with complete extension of elbows and wrists for standardization. Skin, subcutaneous tissue, and palmar aponeurosis were carefully removed. The palmaris brevis muscle was excised and reflected medially to provide unobstructed access, and the palmar fascia over the hypothenar muscles was meticulously cleaned.

The ulnar nerve and artery were exposed in the distal forearm, lateral to the pisiform bone and flexor carpi ulnaris tendon. The structures were traced distally into the ulnar tunnel, where the nerve and artery were radial to the pisiform bone and dissected to the bifurcation point of the ulnar nerve.

Anatomical Measurements

Following exposure, the bifurcation of the ulnar nerve into its superficial and deep branches was carefully identified. The superficial branch, supplying cutaneous innervation to the fourth and fifth digits, was dissected using a probe. The deep branch was traced through the pisohamate hiatus (Figure 1), and its distance from the hook of the hamate was measured using a digital caliper (LCD Electronic Digital Vernier Caliper Gauge Micrometer, 150 mm, 6 inches).

Dynamic Wrist Positioning and Measurements

To evaluate changes in the position of the deep branch of the ulnar nerve, measurements were taken in four wrist positions: Neutral position, Flexion, Extension, Radial and ulnar deviation

In all positions, the distance between the deep branch of the ulnar nerve and the ulnar border of the hook of the hamate was measured in millimeters (mm) using the digital caliper.

Ethical consideration:

The study has been approved by Standing Committee for Scientific Research Ethics- Jazan University (SCSRE) (Ref.no. REC42/1/117).

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4. Results

The positional difference of the deep branch of the ulnar nerve with respect to the hook of the hamate was examined in this study. 30 embalmed hands (15 right and 15 left) were dissected and the distance between the deep branch of the ulnar nerve and the ulnar border of the hook of the hamate measured in a neutral position (D2M1) and contrasted with four movements of the wrist: flexion (D2M2), extension (D2M3), ulnar deviation (D2M4), and radial deviation (D2M5). [Table1]

Positional Changes of the Deep Ulnar Nerve In the neutral position, the mean distance of the deep branch of the ulnar nerve from the hook of the hamate was 2.92 mm ± 0.56 mm. The distance reduced significantly with wrist flexion (2.38 mm ± 0.33 mm) and ulnar deviation (1.96 mm ± 0.33 mm), bringing the nerve closer to the bony structure. In contrast, the nerve migrated from the hook with wrist extension (3.10 mm ± 0.46 mm) and radial deviation (3.12 mm ± 0.40 mm), but these were not significant statistically. [Table 2]

Statistical Analysis Wilcoxon signed-rank tests were used to ascertain positional change difference between wrist movement. Hamate hook distance clearly decreased in f lexion ($p < 0.001$) and ulnar deviation ($p < 0.001$), demonstrating that both movements increase risk of nerve compression. However, wrist extension ($p = 0.107$) and radial deviation ($p = 0.19$) experienced a marginal increase in distance, but differences were not meaningful.

Clinical Implications These findings implicate repetitive wrist flexion and ulnar deviation as potential causes of increased risk for ulnar nerve compression, namely in those whose job entails prolong ed movement of the wrist. This anatomical insight may be useful in limiting surgical and prevention techni ques for ulnar nerve entrapment.

5. Discussion

A thorough understanding of the anatomy and variation of the ulnar nerve and ulnar artery within the distal ulnar compartment is necessary for the diagnosis and management of ulnar nerve compression. The current study evaluated the anatomical relationship between the deep branch of the ulnar nerve and the hook of the hamate, observing dynamic variations that might predis pose the nerve to compression Our observations show that in four of the specimens dissected, the deep branch of the ulnar nerve was associated with the deep branch of the ulnar artery on its radial side within the pisohamate hiatus. These nerves and arteries went on into the mid-palmar space, curving dorsally over the distal margin of the pisohamate ligament and passing under the pisohamate arch. This result concurs with the results of Gross & Gelberman and Uriburu et al., who noted similar anatomical configurations, with the deep ulnar artery branch averaging 1.8 mm from the ulnar border of the hook of the hamate [2,13]. On the contrary, in the remaining 26 specimens, the deep branch of the ulnar nerve was the only content of the pisohamate.

hiatus, superficially overlapped by a small arterial branch to the hypothenar muscles. This anatomical feature is consistent with König et al., who reported that the deep ulnar nerve was the most frequent structure in the deep tunnel, occasionally associated with a small arterial branch. Correspondingly, Lindsey and Watumull reported absence of an arterial conduit running alongside the deep ulnar nerve, instead describing a distal origin of the deep ulnar artery within the canal, where it contributes to formation of the deep palmar arch with the radial artery [14, 15].

In this study, the ulnar nerve deep branch always coursed radially along the ulnar border of the hook of the hamate before coursing deep through the pisohamate arcade in the neutral wrist position. This is rather in contrast to Kwon et al.'s observation that in three out of 28 patients, the ulnar nerve was positioned radially to the hook of the hamate and in the remaining cases ulnarly positioned [11]. The mean distance between the deep branch of the ulnar nerve and the ulnar border of the hook of the hamate in the neutral position was 2.9 mm, which is in close proximity to Netscher et al., who measured this distance to be 3.6 mm in a series of eight patients [16]. One of the primary conclusions drawn from our study was that wrist flexion and ulnar deviation produced a significant radial displacement of

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the deep branch of the ulnar nerve toward the ulnar border of the hook of the hamate. This positional alteration can potentially make the nerve more vulnerable to compression neuropathy, particularly in those patients who are engaging in repetitive wrist motion.

Conversely, radial deviation and wrist extension caused a negligible ulnar displacement of the nerve, positioning it further away from the hamate hook, though once more, these differences w ere not significantly different. Rauch et al., in a study of wrist positions on cyclists using MRI, observed that the deep ulnar nerve branch was in direct contact with the hook of the hamate during hyperextension and ulnar deviation again confirming the risk of nerve entrapment in these wrist positions. On the other hand, a study observed that ulnar neurovascular structures were displaced radially as the wrist transitioned from radial deviation to neutral to ulnar deviation [10, 11].

Repeat collision of the ulnar nerve's deep branch with the hook of the hamate at some angles of the wrist may raise the risk for a compression of the nerve within the distal ulnar tunnel and lead to the motor weakness of thehand. Owing to stiffness in cadaveric tissues, the am ount of displacement of nerve in flexion and ulnar deviation of the wrist is likely larger in live specimens as well and therefore carries with it the additional danger of dynamic compressionin functioning specimens. Implications are severe in respectof clinical diagnosis for entrapment syn dromes of the ulnar nerve, operative repair,and optimum preventative mane uvers in specimens at risk.

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